REORDER BY SPECIFYING

YAWMAN AND ERBE MFG. CO.

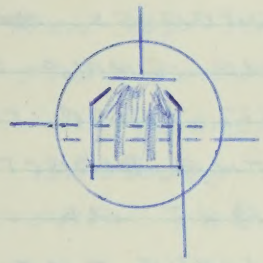
304 T 1/5

THE GAIN ON A PENTODE IS DETERMINED BY THE SCREEN VOLTAGE (SIZE OF RESISTOR)

EVEN LOWER THAN THE SCREEN.

BEAM POWER TUBE.

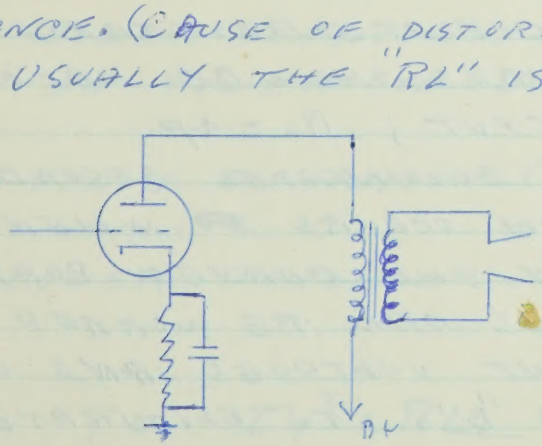
DOES NOT HAVE A SUPRESOR GRID.
BEAM FORMING PLATES TO CONCENTRATE THE ELECTRONS.
SCREEN AND CONTROL GRID WIRES IN LINE.
ELECTRONS MOVE IN SHEETS.



THE BEAM FORMING PLATES HELP THE ELECTRONS TO CONCENTRATE ON PLATE
SUPRESOR ACTION IS OBTAIN BY THE NEGATIVE STREAM OF ELECTRONS REPELING BAK THE SECONDARY ELECT.
THE LOAD RES. IS VERY HIGH.
CAN DELIVER GREAT AMOUNTS OF POWER.

POWER AMPLIFIER.

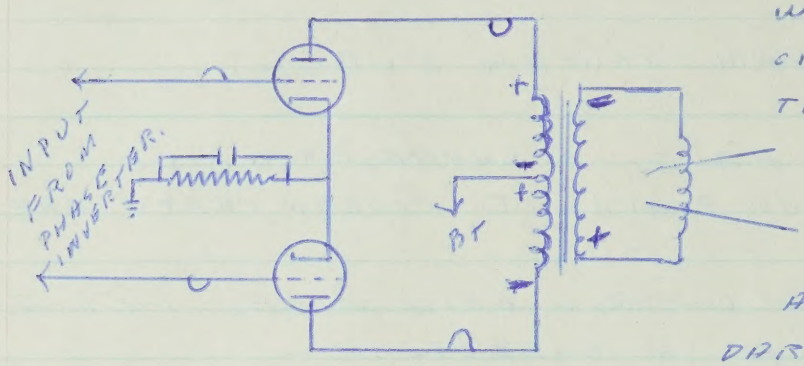
TWO KINDS: SINGLE ENDED
PUSH PULL
SINGLE ENDED OPERATED CLASS "A"
MAXIMUM POWER OUTPUT IS OBTAIN WHEN THE LOAD IMPEDANCE MATCH THE PLATE IMPEDANCE. (CAUSE OF DISTORTION) (BETTER HIGHER) 2 TO 3 TIMES
USUALLY THE "RL" IS SMALLER THAN THE TRIODE
LOWER "μ"
LOAD MUST BE MATCH TO THE OUTPUT Z FOR MAXIMUM POWER TRANSFER.
REFLECTED IMPEDANCE



A POWER AMPL. HAS LESS THAN A ~~μ~~ OF 10.
LOWER "rp" LOWER "RL"
SINGLE ENDED.
Z OF XFORMER DETERMINED BY THE STEADY STATE CURRENT

PUSH-PULL POWER AMPLIFIER

FOR GREATER POWER OUTPUT - GOOD FIDELITY



WHEN THE CURRENT OF OF TUBE IS INCREASING THE CURRENT OF THE OTHER TUBE IS DECREASING. THE CURRENT OF THE FIRST TUBE INDUCES A VOLTAGE IN THE SECONDARY, AND THE CURRENT OF THE SECOND TUBE AS IT DECREASES ~~INDUCE~~ ALSO A VOLTAGE WHICH IS IN THE SAME DIRECTION THEREFORE ADDING TO THE FIRST. SINCE THE CURRENT OF BOTH TUBES ARE OPOSITE IN THE DIRECTION OF THE Bf THEY CANCELL EACH OTHER BUT AS ONE INCREASES THE OTHER DECREASES, AND SINCE THE VOLTAGE IS 180° OUT PHASE, THE INDUCE VOLTAGE IN THE SECONDARY IS INCREASED, BECAUSE AS ONE FIELD IS INCREASING THE OTHER IS DECREASING IN IN THE SAME DIRECTION. THE SECOND OR EVEN HARMONICS DISTORTION PRESENT ON TIRIODES ARE ALMOST ELIMINATED SINCE THEY FLOW IN OPOSITE DIRECTIONS IN THEIR HALFS OF THE XFORMER. THEIREFORE THE LOADS CAN BE ADJUSTED FOR MAXIMUM POWER OUTPUT.

THE IMPEDANCE OF THE PRIMARY SHOULD BE TWICE THE DYNAMIC PLATE RESISTANCE OF ONE TUBE, AND BOTH TUBES SHOULD BE MATCHED FOR MAXIMUM POWER OUTPUT; $R_L = r_p$.

PUSH-PULL THEN ELIMINATES SECOND HARMONIC DISTORTION, WHICH OCCURS ~~WHEN~~ WHEN OPERATING TOO FAR DOWN ON THE CURVED PORTION, THEREFORE THE TUBES CAN BE WORKED HARDER. WITH GREATER INPUT VOLTAGES AND OPERATED AT CLASS "AB$_1$" OR "B". TO ELIMINATE EVEN HARMONICS BOTH TUBES MUST BE EQUAL. SOME TIMES SEPARATE BIAS RESISTORS ARE USED TO ADJUST FOR EQUAL PLATE CURRENTS OR TO BALANCE THE TUBES. IN THE CAT IT IS ASUMED

THAT BOTH TUBES ARE EQUAL THEREFORE ~~IN~~ BOTH CATHODES USED THE SAME RESISTOR. THE BY-PASS CAP. CAN BE ELIMINATED SINCE THE CURRENT OF ONE TUBE IS INCREASING AS THE OTHER IS DECREASING THE VOLTAGE ACROSS THE RESISTOR IS CONSTANT BUT FOR GOOD MEASURE THE CAP. IS ADDED IN MOST CASES.

ANOTHER ADVANTAGE OF THE PUSH-PULL IS THAT THE DIRECT CURRENT COMPONENTS ON THE X-FORMER TRY TO CANCELL EACH OTHER. THUS THE D.C SATURATION OF THE CORE IS AVOIDED. ALSO THE HUM FROM THE POWER-SUPPLY IS ALMOST ELIMINATED.

RESISTIVE LOADS CAN'T BE USED IN POWER AMP. BECAUSE THE RESISTOR WOULD CUT TOO MUCH CURRENT FROM THE CKT. IN OTHER WORDS ~~HIGH~~ D.C. RESISTANCE

REFLECTED IMPEDANCE FROM THE SECONDARY AND PRIMARY SHOULD BE MATCHED TO THE TUBES FOR MAXIMUM POWER OUTPUT BUT FOR MINIMUM DISTORTION SHOULD BE 2 TO 3 TIMES.

$$\text{PLATE EFFICIENCY} = \frac{\text{POWER OUT}}{\text{POWER IN } (E_{BB} \times I_{BB})} \times 100 = \%$$

$$\text{POWER SENSITIVITY} = \frac{\text{POWER OUT}}{E_g^2} \times 10^6 \text{ MMHOS}$$

POWER SENSITIVITY, DOES NOT DRAW GRID CURRENT ON POWER STAGES.

PLATE DISSIPATION (LOSS) = POW. IN — POW OUT.

$$\text{POWER. AMPLI.} = \frac{\text{POWER OUT}}{\text{POWER IN (GRID)}}$$

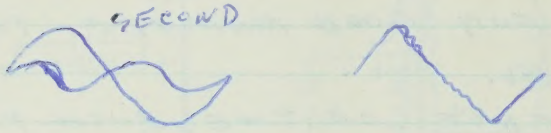
$$P = I_P^2 \times RL.$$

DISTORTION.

FREQUENCY, PHASE AND HARMONIC. (AMPLITUD)

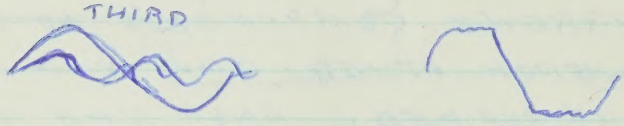
HARMONIC OR AMPLITUD DIST.

SECOND



EVEN HRMONICS PRODU
SAW TOTH WAVE

THIRD



ODD HARMONICS PRODUCE
SQUARE WAVE.

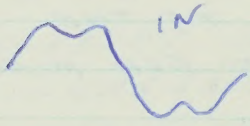
AN INFINITY NUMBER ADDED ALGEBRAICLY

CAUSES: NON-LINEAR OPERATION
HYSTERISIS IN COILS

FREQUENCY DIST.

SOME FRE. AMPLIFIED MORE THAN OTHERS.

IN



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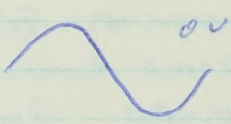
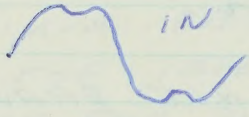


CAUSED BY INDUCTIVE AND CAPACITANCE ELEMENTS.

PHASE DISTOR.

SHIFTED HARMONICS

IN



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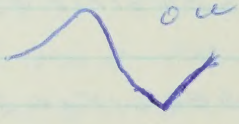


CAUSED BY COUPLING CKTS.

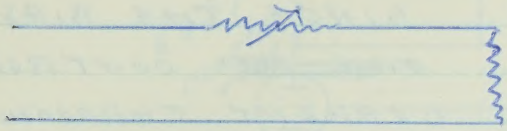
VOLTAGE REGULATION

TO CONTROL THE BT VALUE FROM LINE CHANGES AND VARIATIONS OF LOAD AND FREQUENCY

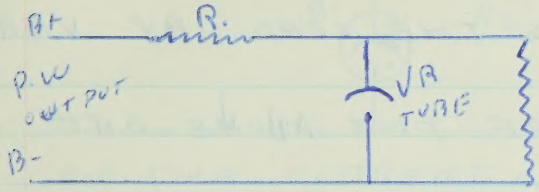
TWO TYPES OF REGULATOR CKTS.
FOR VOLTAGE AND CURRENT

VR. TUBES (COLD CATHODE)

IONIZATION OF GAS BY POTENTIAL DIFFERENCE BETWEEN PLATE AND CATHODE. RESISTANCE OF TUBE VARIES WITH CURRENT FLOW.



MANUAL VOLTAGE REGULATOR



THE VR. TUBE IN PARALELL WITH THE LOAD TRYS TO KEEP A CONSTANT VOLTAGE ACROSS IT. VR TUBES RATED BETWEEN 105 TO 150 VOLTS

30 Ma. MAXIMUM - 5 Ma ~~MINIMUM~~.

~~IF THE LOAD C~~ IF THE SUPPLY VOLTAGE DROPS THE VOLTAGE ACROSS VR. TRYS TO DROP, INSTEAD THE GAS IN THE VR TUBE DEIONIZES SLIGHTLY, INCREASING THE R. AND DECREASING THE CURRENT TROUGHT IT THE CURRENT IN R IS ALSO DECREASES BY THE SAME AMOUNT. SINCE THE CURRENT IS LESS THE VOLTAGE DROP ACROSS R IS LESS, THEREFORE BRINGING THE VOLTAGE ACROSS THE VR. TUBE TO THE RIGHT VALUE.

~~IF THE~~ THE PROCESS IS REVERSED IN THE OPOSITE CASE— SUPPLY VOLT. GOES UP.

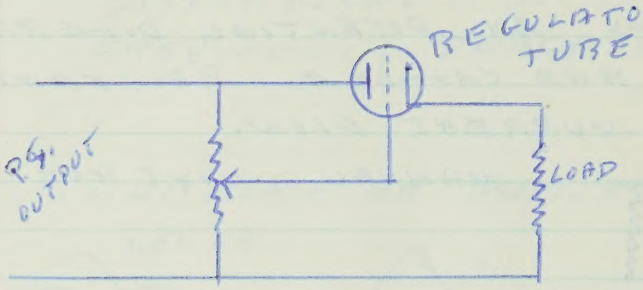
SAME THING IF LOAD VARIES. IF THE LOAD DECREASES- THE VOLTAGE WILL TRY TO GO UP, SO VR CURRENT INCREASES, ALSO IN R. DROPINGTHE VOLTAGE ACROSS VR.

IF MORE VOLTAGE REGULATION IS NEEDED THAN THE TUBE AVALIABLE TWO OR MORE EQUAL VR. TUBES MAY BE CONECTED IN SERIES.

THE DISADVANTAGES OF THIS CKT. IS THE CURRENT LIMITATIONS OF THE VR. TUBES.

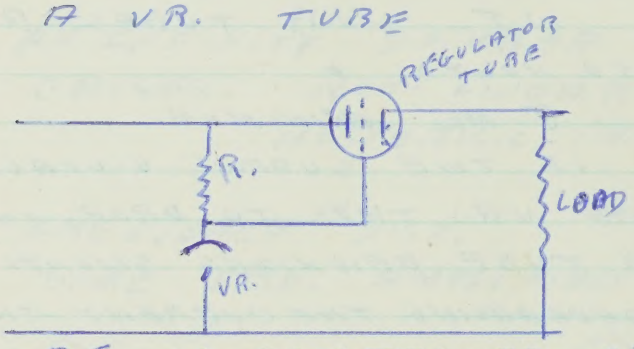
FOR ~~CURR~~ HIGHER CURRENT VOLTAGE REGULATORS VACUM TUBE ARE USED HEAVY DUTY TYPE. USUALLY POWER AMPLI. (GRID CONTROLED REGULATOR)

SIMPLE VACUMTUBE REGULATOR.



THE TUBE ACTS AS A VARIABLE RESISTANCE SINCE THE BIAS VOLTAGE ~~ARE BE~~ CONTROLS THE CURRENT THROUGH THE TUBE THE BIAS VOLTAGE CAN BE VARIED TO CONTROL THE VOLTAGE ACROSS THE LOAD BY VARYING THE TUBE CURRENT.

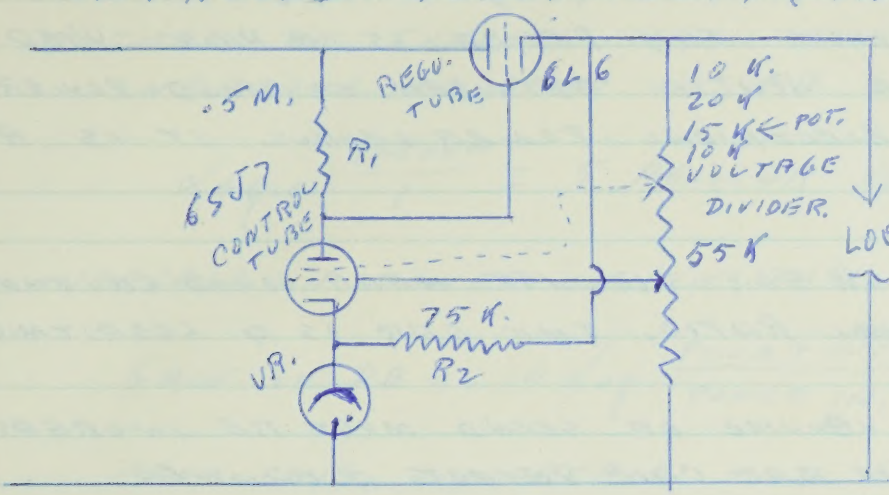
AN IMPROVEMENT OF THE ~~A~~ BE CKT WITH A VR. TUBE



IN THIS TYPE THE BIAS VOLTAGE IS KEPT CONSTANT BY THE VR TUBE THE CURRENT IN THE VOLTAGE REGULATOR TUBE IS CONTROLED BY THE BIAS VOLTAGE. IF THE LOAD CURRENT INCREASES THE VOLTAGE WILL TRY TO GO DOWN, AS THIS HAPENS THE VOLTAGE ACROSS THE VR. TUBE AND THE RESISTOR DROPS. BUT THE VOLTAGE ACROSS THE VR. WILL BE CONSTANT THEREFORE ~~THE~~ THE DROP ACROSS DROPS. AT THAT INSTANT THE BIAS VOLTAGE BECOMES LESS NEGATIVE INCREASING THE CURRENT TROUHGH THE REGULATOR TUBE AND DECREASING THE VOLTAGE DROPED ACROSS IT IF THE CKT IS PROPERLY DESIGNED THIS VOLTAGE WILL EQUAL THE ~~VOLTAGE~~ DROP IN VOLTAGE AT THE LOAD.

IF THE LINE VOLTAGE INCR~~E~~ASES THE BIAS VOLTAGES INCREASES) THE EFFECTIVE RESISTANCE OF THE TUBE INCREASES DROPING MORE VOLTAGE ACROSS IT KEEPING THE OUTPUT CONSTANT.

IMPROVED HEAVY DUTY (THREE TUBES)



THIS TYPE OF CKT IS CAPABLE OF HANDLING LARGE AMOUNTS OF CURRENT.

THE BIAS OF THE REGULATOR TUBE DEPENDS ON THE CURRENT FLOW OF THE CONTROL TUBE THE GREATER THE CURRENT, THE MORE NEGATIVE IS THE GRID AND THE HIGHER THE EFFECTIVE RESISTANCE OF THE REGULATOR TUBE AND VICE VERSA.

THE FLOW OF CURRENT ON THE CONTROL TUBE DEPENDS ON THE BIAS ON ITS GRID. THE CATODE IS KEPT AT A CONSTANT POTENTIAL BY THE VR. TUBE. THE GRID VOLTAGE IS TAPPED AT A DIVIDER ACROSS THE OUTPUT IN PARALELL WITH THE TUBE.

IF THE VOLTAGE ACROSS THE LOAD RISES, THE GRID VOLTAGE OF THE CONTROL ALSO RISES, INCREASING THE CURRENT FLOW IN THE CONTROL TUBE MAKING THE GRID TAP FOR THE REGULATOR TUBE MORE NEGATIVE THIS WILL EFFECTIBLY RISE THE RESISTANCE OF THE REGULATOR TUBE CHOSING IT TO DROP MORE VOLTAGE (~~MORE~~ LESS CURRENT FLOW) BRINGING DOWN THE VOLTAGE ACROSS THE LOAD. THE ACTION IS SIMILAR BUT INVERSE IF THE LOAD VOLTAGE DROPS. SAME THING HAPPENS IF THE LINE VOLTAGE VARIES. A PENTODE MAY BE USED AS A CONTROL TUBE FOR MORE CURRENT. TUBES MAY BE PUT IN PARALELL.

R_2 SERVIES TO PUT A POSITIVE POTENTIAL ON THE VR. SO THE GAS CAN IONIZED WHE POWER SUPPLY IS STARTED.

THE DECIBEL (DB) = $\frac{\text{BEL}}{10}$

BY DEFINITION THE DECIBE IS A UNIT USED TO EXPRESS. THE RATIO BETWEEN TO SOUND POWER LEVELS OR TWO ELECTRICAL POWER LEVELS. IT IS A .10 OF A BEL

THE HUMAN EAR DOES NOT HEAR SOUND ON THEIR DIRECT POWER ~~LEVEL~~ RATIO. THE EAR IS A LOGRITMIC DEVICE.

IF GIVEN VOLUME OF SOUND MUST BE INCREASED 25% BEFORE THE EAR CAN DETECT A CHANGE

TO COMPARE TO DIFFERENT SOUND POWERS THE UNIT BEL IS USED WHICH IS THE LOG. OF 10 TO THE BASE 10 OR $\log_{10} 10 = 1$ BEL. THE DECIBEL (DB) IS ONE TENTH OF A BEL AN IT IS USED BECAUSE A CHANGE OF ONE DB. OF SOUND INTENSITY CORRESPONDS TO THE RATIO OF 1.25 TO 1. A CHANGE OF ONE D.B IS ABOUT THE MINIMUM CHANGE IN SOUND TAT THE EAR CAN HEAR.

IF TWO SOUNDS BEAR A POWER RATIO OF 1.25 TO ONE THE EAR WILL DETECT THAT ONE IS LOUDER THAN THE OTHER, NO MATER ~~WAT~~ WHAT THE VALUES ARE, THAT IS; IF TWO SOUNDS OF 10 AND 12.5 WATTS ARE COMPARED ~~THEY~~ BY THE EAR THE SAME DIFFERENCE WILL BE NOTED AS IF TWO SOUNDS OF 1 AND 1.25 WATTS WERE COMPARED. IT IS NOT THE ABSOLUTE VALUE BUT THE RATIO WHAT COUNTS.

WHEN USING DB, EACH TIME A SOUND ~~WATTS~~ (OR POWER OUTPUT OF AN AMPL.) IS INCREASED BY A RATIO OF 1.25 TO 1 WE SAY WE HAVE ADDED 1 D.B.

IF TWO POWER ARE TO BE COMPARED, THE RELATIVE ~~OF~~ VALUE IN DB IS FOUND BY THIS FORMULA

DB - FOR →

$$DB = 10 \log_{10} \frac{P_2}{P_1}$$

THE FACTOR 10 COMES HERE BECAUSE WE ARE WORKING IN D.B AND NOT ON BELS.

EXAMPLE: COMPARE THE POWER OF ORDINARY CONVERSATION TO THAT OF THUNDER 100,000 TIMES MORE POWER- INCREASE OF SOUND ON D.B.

$$\text{Log}_{10} \frac{100,000}{1} = 5 \text{ BELS. OR } 10 \text{ Log } \frac{100,000}{1} = 50 \text{ D.B.}$$

INCREASE IN POWER ON AN AMPL. =

$$\text{GAIN IN DB} = 10 \text{ Log } \frac{\text{POWER OUT}}{\text{POWER IN.}}$$

FROM THIS WE OBTAIN THE GAIN OF AN AMPL. WHICH HAS 5 WATTS INPUT AND 10 WATTS OUTPUT

$$10 \text{ Log } \frac{10}{5} = 10 \text{ Log } 2 \text{ ; Log } 2 = .3010 \times 10 = 3.01 \text{ D.B GAIN}$$

FROM THIS WE SEE THAT

A POWER RATIO OF 1 = 0 DB GAIN
" " " 10 = 10 " "
" " " 100 = 20 " "
" " " 1000 = 30 " "
AND SO ON.

ALSO IF ONE D.B INCREASE APPROXIMATES A POWER RATIO OF 1.25 TO 1 THEN

D.B		APR. POWER RATIO
3	=	2
4	=	2.5
6	=	4
9	=	8
10	=	10
20	=	100
23	=	200
30	=	1000

RULE → REMEMBER A RULE TO REMEMBER IS THAT 3 DB. INCREASE REPRESENT DOUBLE THE POWER AND VICE VERSA.

AND THAT 1 D.B VARIES THE POWE BY 25%

TO FIND THE NUMBER OF DB BY WHICH TWO POWERS DIFFER, FIRST DETERMINE THE RATIO, THEN THIS RATIO IS LOOKED UP ON THE LOGARITHMS TABLE TO THE BASE 10 AND THE FIGURE OBTAINED MULTIPLIED BY TEN

IF THE POWER OUTPUT IS GREATER THAN THE INPUT THERE IS A DB GAIN +dB IF THERE IS A LOSS —DB.

WHEN SEVERAL AMPL. ARE HOOKED UP TOGETHER WE MULTIPLY THE AMPLIFICATION. BUT IN THE DECIBEL WE ADD UP THE DB GAINS OR LOSSES OF EACH AMPL.

VOLTAGE AND CURRENT RATIOS:

SOME TIMES IS NECESSARY TO EXPRESS THE RATIOS OF TWO POWERS ~~IN~~ IN TERMS OF VOLTAGE OR CURRENT

SINCE $P = \frac{E^2}{R}$ OR I^2R THEN WE HAVE

$$\text{DB GAIN} = 10 \log \frac{\frac{E_2^2 \text{ OUTPUT}}{R_2 \text{ OUTPUT}}}{\frac{E_1^2 \text{ INPUT}}{R_1 \text{ INPUT}}} \quad \text{OR} \quad DB = 20 \log \frac{E_2 \sqrt{R_1}}{E_1 \sqrt{R_2}}$$

IF THE R. ARE THE SAME THEN

$$DB = 10 \text{ Log} \left(\frac{E_2}{E_1} \right)^2 \text{ OR } 20 \text{ Log } \frac{E_2}{E_1}$$

SIMILARLY

$$DB = 10 \text{ Log } \frac{I_2^2 R_2}{I_1^2 R_1} \text{ OR } 10 \text{ Log} \left(\frac{I_2 \sqrt{R_2}}{I_1 \sqrt{R_1}} \right)^2$$

$$\text{OR } 20 \text{ Log } \frac{I_2 \sqrt{R_2}}{I_1 \sqrt{R_1}}$$

IF THE RESISTANCES ARE EQUAL THEN.

$$DB = 20 \text{ Log } \frac{I_2}{I_1}$$

IMPORTANT →

THE FACTOR 20 ARISES FROM THE FACT THAT WHEN A LOG IS SQUARED THE NUMBER IS DOUBLED SO FOR POWER RATIOS THE DB IS 10 TIMES THE LOG AND FOR VOLTAGE & CURRENT IT IS 20 TIMES THE LOG.

TO SOLVE FOR ONE OF THE POWER

$$20 \text{ DB GAIN} = 10 \log \frac{100}{P_{IN}}$$

FIRST DIVIDE 20 D.B BY 10 = 2 FIND ANTILOG OF 2 = 2 IS THE CHARACTERISTIC - NO MANTISA SO 100 IS THE ANTILOG. NOW THEN THE RATIO OF $\frac{100}{P_{IN}} = 100$ $\frac{100}{100} = 1$ P-IN.

ANOTHER: $25 \text{ DB} = 10 \log \frac{P_{OUT}}{2 \text{ WATTS}}$

DIVIDE DB BY 10 = 2.5 ANTI LOG = FIND ANTILOG OF 5; 2 INDICATES PLACE OF DECIMAL POINT ANTILOG OF 2.5 = 316

SO $\frac{P_{OUT}}{2} = 316$ BRING 2 ABOVE $316 \times 2 = 632$

$P_{OUT} = 632$

POWER LEVELS - REFERENCE LEVELS

AN EXPRESSION OF THE GAIN OF AN AMPLIFIER IS MEANINGLESS UNLESS IT IS SAY TO WHAT REFERENCE LEVELS IF WE SAY AN AMPL. HAS A GAIN OF 30 D.B IS MEANINGLESS IN TERMS OF ACTUAL POWER OUTPUT, ALL WE SAY IS THAT THE POWER OUTPUT IS 1000 TIMES THE POWER INPUT

SEVERAL ZERO-DB LEVELS ARE IN USE BUT THE MOST COMMON ARE 0 DB. = .006 (6 MILLIWATTS) AND 0 D.B = .001 (1 MILLIWATT).

THUS WE MAY GE

$$\text{POWER OUTPUT} = +30 \text{ DB} = 10 \log \frac{P}{.006}$$

THE ANSWER. $3 = \log \frac{P}{.006}$ ANTILOG = 1000

1000 X .006 = 6 WATTS OUTPUT.

TELEPHONE ENGINEERS USE THE 0 DB = 6 MILLIW
OR 1.732 VOLTS IN 500 Ω IMPEDANCE
OTHER SOUND ENGINEERS USE THE 0 DB = 1 MILLIW
OR .775 VOLTS IN 600 Ω IMPEDANCE

DECIBEL METERS- AN A.C METER CALIBRATE
TO READ IN DB WHEN PLACED ACROSS A CERTAIN
RESISTANCE

THE VOLUME U.T. (V.U.)
THE VOLUME UNIT IS A REFERENCE UNIT ADAP-
TED AS A STANDARD WORK WITH DB.
AND IT IS MERELY A DB WHICH ALWAYS HAS
A REFERENCE POWER LEVEL OF 1 MILLIWATT
AND A REFERENCE RESISTANCE OF 600 Ω
0 DB (VU) = 1 MW. IN 600 Ω

NEGATIVE DB ARE USED FOR MICROPHONES
OR PHONOGRAPHS PICK-UP SINCE THEIR OUT
PUTS IS SO SMALL THAT IT DOESN'T REACH
THE REFFERENCE LEVEL OF 6 MILLIWATTS OR 1 MW.

A.C THEORY

REVIEW OF MAGNETISM & ELECTROMAGNETS.

STRENGHT OF TWO MAGNETS IN GILBERTS.

ELECTRO MAGNETISM - AN ELECTRICAL CURRENT FLOWING IN A CONDUCTOR SETS UP A MAGNETIC FIELD. THE STRENGTH OF THE FIELD DEPEND ON THE CURRENT

LEFT HAND RULE - THUMB DIRECTION OF CURRENT FLOW
FINGERS DIRECTION OF FIELD

COIL - IF THE CONDUCTOR IS WOUND IN A COIL THE FIELD STRENGTHENS. THE FIELDS AROUND EACH TURN ADD TO MAKE THE FIELD.

THE FIELD AROUND A COIL IS SIMILIAL TO THAT OF A BAR MAGNET. WITH THE LINES OF FORCE MAKING A NORTH AND SOUTH POLE
LEFT HAND RULE FOR COILS OR SOLENOIDS IS THE SAME AS FOR A SINGLE CONDUCTOR THE THUMB WILL POINT TO THE NORTH POLE.

ELECTRO MAGNET - THE MAGNETIC FIELD AROUN A COIL IS GRIATER INCREASED IF THE COIL IS WOUND AROUND A MAGNETIC MATERIAL. THE REASON FOR THIS IS THAT IRON OR OTHER MAGNETIC MATERIAL ARE MORE PERMEABLE THAN AIR

PERMEABILITY - THE RATIO OF LINES OF FLUX PASSING THROUG AN AREA WHEN IT IS OCCUPIED BY A SUBSTANCE TO THE LINES OF FLUX PASSING THROUG AIR (ABILITY TO PASS MAGNETIC LINES OF FORCE).
PERMEABILITY IS NOT A FIXED UNIT, IT VARIES WITH THE CURRENT TROUGH THE COIL, AND IT VARIES IN ALL CORES.

MAGNETOMOTIVE FORCE - MAGNETIC CKT.

THE FLUX IN A FIELD DEPENDS ON THE MAGNETOMOTIVE FORCE AND THE RELUCTANCE OF IT

$$\text{FLUX} = \frac{\text{MAGNETOMOTIVE FORCE (M.M.F)}}{\text{RELUCTANCE}}$$

$$\phi = \frac{F}{R}$$

ϕ = FLUX
F = M.M.F IN GILBERTS
R = RELUCTANCE IN OERSTEDS.

THE RELUCTANCE IS NOT CONSTANT BUT DEPENDS ON THE FLUX.

THE MAGNETIZING FORCE SET UP DUE TO CURRENT FLOWING IN A COIL OR SOLENOID IS KNOWN AS THE MAGNETOMOTIVE FORCE. (M.M.F)
THE M.M.F IS PROPORTIONAL TO THE CURRENT IN AMPERES FLOWING IN THE COIL & THE NUMBER OF TURNS IN THE COIL.

MMF IN GILBERTS $= N \times I \times 1.25$
N = NUMBER OF TURNS
I = CURRENT IN AMPS.

THE PRACTICAL UNIT IS AMPERE-TURNS. $(N \times I)$

SATURATION OF A CORE IS REACHED WHEN AN INCREASE OF MAGNETIZING FORCE PAST A CERTAIN POINT WILL PRODUCE NO MORE INCREASE ON FLUX DENSITY.

HYSTERESIS LOSS IS AN EFFECT OF THE FACT THAT NOT ALL ENERGY IS USEFULLY EMPLOYED IN PRODUCING FLUX BECAUSE OF THE LAGGING OF THE MAGNETIZATION AND DEMAGNETIZATION OF THE CORE WITH THE A.C.

ELECTROMAGNETIC INDUCTION

IF A CONDUCTOR MOVES THROUGH A MAGNETIC FIELD OR VICEVERSA AN ELECTRIC CURRENT IS SET UP IN R THE CONDUCTOR. THIS EFFECT IS CAUSED BY THE FLUX LINES CUTTING THE CONDUCTOR AN IDUCING ON IT AN EMF. THIS EMF WILL ONLY BE IDUCED WHEN THE CONDUCTOR IS MOVING THROUGH THE FLUX LINES.

THE SAME EFFECT WILL BE OBSERVE IF A MAGNET IS PUT INSIDE A COIL.

FACTORS DETERMINING THE MAGNITUD OF AN IDUCED EMF. ON A COIL

1 NUMBER OF CONDUCTORS (TURNS) BEING CUT BY THE FLUX LINES

2 SIZE OF THE MAGNETIC FIELD (STRENGTH)

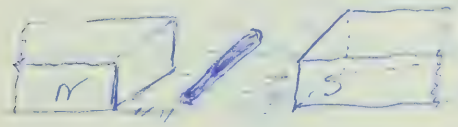
3. RATE OF SPEED OF THE RELATIVE MOTION BETWEEN THE CONDUCTOR AND THE FIELD

INCREASING ANY OF THIS FACTORS WILL INCREASE THE INDUCED EMF.

IF 10^8 LINES ARE CUT PER SECOND THE WILL INDUCED - 1 VOLT

THE ELECTRIC GENERATOR

THE MAXIMUM AMOUNT OF INDUCED EMF IS ACCOMPLISHED WHEN THE CONDUCTOR IS MOVED AT RIGHT ANGLES TO THE LINES OF FLUX



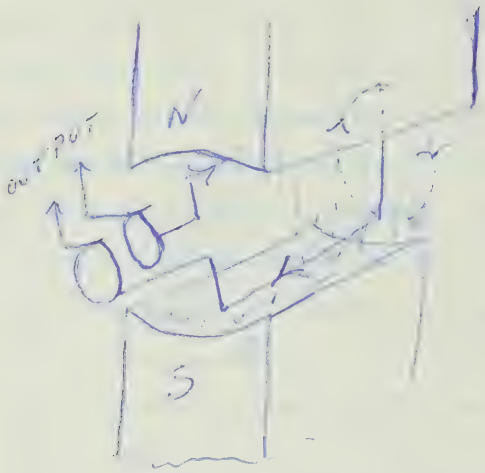
A SIMPLE A.C. GENERATOR. TWO PERMANENT MAGNETS ESTABLISH [illegible] CUTTING THE FLUX LINES. THE DIRECTION WILL BE REVERSE EVERY TIME THE CONDUCTOR IS MOVED UP OR DOWN GIVING US AN INDUCE A.C EMF.

IF THE CONDUCTOR WOULD PARALELL TO THE FLUX LINES THE INDUCED EMF WOULD BE ZERO.

AN ELECTRIC GENERATOR IS A DIVICE TO CONVERT MECHANICAL ENERGY TO ELECTRICAL ENERGY

.N

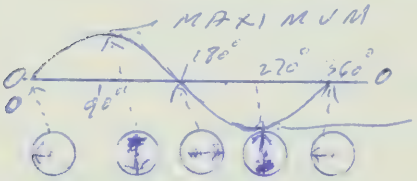
THE SIMPLE TWO POLE A.C GENERATOR.



THE TURN OF WIRE IS ROTATED IN THE FIELD AT ANY PARTICULAR INSTANT THE EMF INDUCED IN ONE SIDE IS EQUAL AN OPOSITE TO THE OTHER SIDE BUT THEY ADD BECAUSE BOTH SIDES ARE CONNECTED IN THE BACK.

AS THE TURN MOVES, CLOSEST TO THE MAGNETS THE MAXIMUM PEAK OF INDUCED EMF IS REACHED THE IT DECREASES AS THE TURNS START TO MOVE PARALELL WITH THE FLUX LINES TILL IT REACHES ZERO, AS THE TURN CONTINUES TO ROTATE THE EMF INCREASES IN THE OPOSITE DIRECTION UNTILL IT REACHES ANOTHER PEAK WHEN BOTH SIDES ARE CLOSEST TO THE OPOSITE MAGNETS, THE AS THE ROTATION CONTINUES THE EMF DECREASES TO ZERO AGAIN.

THIS IS THE COMPLETE CYCLE.



GENERATION OF A SINE WAVE

BY THIS SYMPLE DEMONSTRATION IT CAN BE SEEN THE ACTION OF AN A.C GENERATOR.

THE ACTUAL GENERATOR IS MORE COMPLICATED THE MAGNETS ARE ELECTRO-MAGNETS, AND THERE IS MANY TURNS OF WIRE IN THE COIL.

EACH SIDE OF THE COIL IS CONECTED TO A COLLECTOR RING, WHERE THE OUTPUT IS CONECTED THROUGH A CARBON BRUSH.

THE ROTATION IS COUNTER CLOCK WISE

ONE REVOLUTION IS ONE CYCLE..

FOR SOME GENERATORS THERE IS A DIFFERENCE MECHANICAL DEGREES AN ELECTICAL DEGREES SINCE FOR EACH 45° MECH. THERE IS 90° ELECTRICAL- IN OTHER WORDS FOR EACH REVOLUTION TWO CYCLES.

REFER BACK TO NOTES FOR VALUES OF A SINE WAVE.

RMS. PEAK, AVERAGE ETC.

PHASE & PHASE RELATIONSHIP

PHASE IS THE DIFFERENCE IN TIME BETWEEN ANY POINT OF CYCLE AND THE BEGINING OF THE CYCLE.

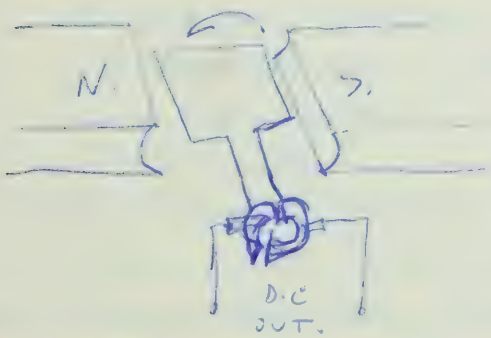
PHASE DIFFERENCE IS THE DIFFERENCE IN TIME BETWEEN ANY TWO CYCLES. EXPRESED IN ELECTRICAL DEGREES.

THE CURRENT AND THE VOLTAGE CAN BE IN PHASE OR OUT OF PHASE ONE CAN LEAD OR LAG THE OTHER.

IF THE PHASE DIFFERENCE OF TWO CYCLES IS $\frac{1}{4}$ CYCLE THE DIFFERENCE IS 90° IF THEY ARE $\frac{1}{2}$ A CYCLE IT IS 180° AND SO ON.

D.C GENERATOR.

THE D.C. GENERATOR IS THE SAME AS THE A C GENERATOR. THE ONLY DIFFERENCE IS THE COLLECTOR RINGS WHICH IN THIS CASE ARE CALLED COMMUTATOR THE COMMUTATOR IS NOTHING MORE THAN A SWITCH TO KEEP THE CURRENT FLOWING IN THE SAME DIRECTION, BY REVERSING THE BRUSHES AT THE PROPER TIME WITH RESPECT TO THE ROTATING COIL.



AS THE COIL ROTATES AND THE DIRECTION OF THE INDUCED EMF IS REVERSED AS THE COIL CUTS IN THE LINES AT THE DIFFERENT POLES THE COMMUTATOR OR SEGMENT ARE IN CONTACT WITH THE BRUSHES AT THE TIME THAT THE EMF IS ZERO CONTACT IS BROKEN, WHE THE CURRENT STARS FLOWING IN THE OPPOSITE DIRECTION THE COMMUTATOR HAS BEEN SWITCHED GIVING A UNIDIRECTIONAL CURRENT. TO ELIMINATE THE RIPPLE MANY COILS AND SEGMENTS ARE USED

INDUCTANCE

~~INDUCTANCE~~ = ANY CHANGE

NEWTON'S LAW - FOR ANY FORCE THERE IS AN OPOSITE FORCE (FOR ANY ACTION THERE IS A REACTION)

INDUCTANCE OPPOSITION TO CHANGE IN CURRENT
CAPACITANCE - " " " " VOLTAGE.

SELF INDUCTANCE -

ANY CHANGE IN CURRENT IN A CONDUCTOR CAUSES A CHANGE IN THE MAGNETIC FIELD AROUND IT. THIS CHANGE OF FLUX CAUSES AN INDUCED EMF IN THE CONDUCTOR IN THE OPOSITE DIRECTION THAN THE ORIGINAL CURRENT CALLED COUNTER EMF (CEMF).

IN A COIL THE INDUCED "CEMF" IS MUCH GREATER THAN A SINGLE CONDUCTOR BECAUSE IT IS THE SUM OF THE INDUCED EMF IN ALL THE TURNS. THUS IF THE CURRENT IS VARYING. THE CEMF TRIES TO OPPOSE THE CHANGE.

THE ABILITY OF A CKT TO GENERATE A CEMF IS KNOWN AS THE INDUCTANCE OF THE CKT, THEREFORE THE GREATER THE CHANGE, THE GREATER THE INDUCTANCE.

FACTORS WHICH DETERMINE THE CEMF.

1) - NUMBER OF TURNS OF THE COIL.
2) - RATE OF CHANGE OF CURRENT (FREQUENCY).
3) - GEOMETRY OF THE COIL AND TYPE OF CORE.

LENZ'S LAW RESTATED: AN INDUCED EMF ALWAYS HAS SUCH A DIRECTION AS TO OPPOSE THE ACTION THAT PRODUCES IT.

THE INDUCTANCE OF A COIL IS PROPORTIONAL TO THE SQUARE OF THE NUMBER OF TURNS.

SYMBOL FOR INDUCTANCE = L

UNIT - - HENRY.

$$L = \frac{.4\pi N^2 \mu A \times 10^{-8}}{4\pi l}$$

.4π MATHEMATICAL CONSTANT

N = NUMBER OF TURNS

μ = PERMEABILITY OF CORE IN ELECTROMAGNETIC UNITS

A = CROSS-SECTIONAL AREA OF CORE IN CM^2

l = MEAN LENTH OF THE CORE.

$$CEMF = -L \frac{\Delta i}{\Delta t}$$ ($\frac{\Delta i}{\Delta t}$ = RATE OF CHANGE OF CURRENT)

Δi SMALL CHANGE IN CURRENT

Δt SMALL INTERVAL OF TIME.

$$L \text{ IN HENRY'S} = \frac{e \text{ - INDUCED VOLTAGE}}{\frac{\Delta i}{\Delta t}}$$

EXAMPLE: IF THE CURRENT IS CHANGING 1 AMP PER SECO
AND THE INDUCED VOLTAGE IS 2V. THE COIL HAS

$\frac{2}{1}$ = 2 HENRY'S.

F↑ L↑
F↑ CEMF↑

EXAMPLE TWO: $CEMF = -L \frac{\Delta i}{\Delta t}$.

A COIL OF 1 HENRY
CURRENT CHANGE FROM 2 TO 1 AMP
IN TIME OF $\frac{1}{10}$ SECOND

$$CEMF = -1 \times \frac{1}{.10} = -10 \text{ VOLTS.}$$

IF THE TIME OF CHANGE IS DECREASE THE INDUC
CEMF IS INCREASE OR F↑CEMF↑

A CKT HAS THE INDUCTANCE OF 1 HENRY WHEN A
CURRENT CHANGE OF 1 AMP-PER-SECOND CAUSES A CEMF
OF 1 VOLT.

INDUCTANCE IN SERIES:=

OPPOSING = $L_1 + L_2$ [illegible] $- 2M$ (2M = MUTUAL INDUC-

ADDING = $L_1 + L_2$ [illegible] $+ 2M$ TANCE X 2

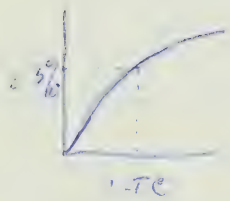
NON-INDUCTIVE COILS - TO CANCEL INDUCTANCE)

TWO WAYS:
WINDINGS OF THE COIL ARE REVERSED ABOUT HALF-WAY. TROUGH THE COIL

THIS METHOD THE UPPER FIELD IS CANCELLED BY THE LOWER FIELD SINCE THEY ARE IN OPPOSITE DIRECTIONS.

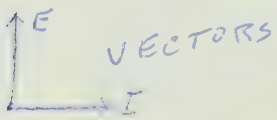
OR COILS WITH SEVERAL LAYERS ONE ALTERNATES THE DIRECTION OF THE WINDINGS EVERY OTHER LAYER.

TIME CONSTANT OF L-R CKT - $TC = \frac{L}{R}$



(MORE LATER)

VOLTAGE AND CURRENT IN AN INDUCTOR.
IN AN IDUCTOR THE VOLTAGE LEADS THE CURRENT BY 90° E L I.



MUTUAL INDUCTANCE (M)

TRANSFER OF ENERGY FROM ONE CKT TO ANOTHER BY THE MUTUAL COUPLING OF THEIR MAGNETIC FIELDS

IF TWO COILS ARE PLACE NEAR EACH OTHER IN SUCH A MANNER THAT THE FLUX SET UP BY THE CHANGING CURRENT IN ONE INDUCES AN EMF IN THE OTHER. MUTUAL INDUCTANCE EXISTS BETWEEN THEM

THE EMF INDUCED IN THE SECOND COIL IS OPPOSITE IN DIRECTION TO THE APPLIED EMF TO THE FIRST ONE. SINCE IT IS SET UP BY THE SAME FORCE WICH SET UP THE CEMF IN THE FIRST ONE.

THE SYMBOL IS "M"

THE UNIT - HENRY

THE AMOUNT OF "M" DEPENDS ON THE "L" OF EACH COIL AND THE COUPLING BETWEEN THEM. THE COUPLING DEPENDS ON THE POSITION OF THE TWO COILS, THE PERMEABILITY OF THE MATERIAL BETWEEN THEM. IF ALL THE LINES OF FLUX CUT THE SECONDARY = 100% COUPLING OR UNIT COUPLING

$$\text{MUTUAL INDUCT.} = \frac{E \text{ (INDUCED VOLT. IN SECONDARY)}}{\frac{\Delta i}{\Delta t} \text{ (RATE OF CHANGE IN PRIMARY) (IN AMPERE PER SECOND)}}$$

$$E \text{ (INDUCED VOLTAGE IN SECONDARY)} = M \times \frac{\Delta i}{\Delta t}$$

THE TRANSFORMER

TRANSFER OF ENERGY BY MUTUAL INDUCTANCE

NOT 100% EFFICIENT DUE TO LOSSES.

HYSTERESIS LOSS: LOSS OF ENERGY BY THE LAG OF MAGNETIZATION AND DEMAGNETIZATION OF THE STEEL CORE BEHIND THE A.C. IN THE CKT.

SATURATION LOSS: LOSS OF ENERGY DUE TO THE SATURATION OF THE CORE BY FLUX LINES. PUTING AIR GAPS ON THE CORE HELPS TO ELIMINATE SOME OF THE SATURATION LOSS.

EDDY CURRENTS: INDUCE CURRENTS IN THE CORE REDUCED BY LAMINATING THE CORE

COPPER LOSS: LOSS BY THE [illegible] THE WIRE.

TRANSFORMERS CAN BE STEP-UP OR STEP DOWN - DEPENDING ON THE TURNS RATIO OF THE PRIMARY TO THE SECONDARY.

I - R A PERFECT TRANSFORMER. THE RATIO OF THE PRIMARY AND SECONDARY VOLTAGE IS EXACTLY EQUAL TO THE TURNS RATIO.

$$\frac{N_P}{N_S} = \frac{E_P}{E_S}$$ N - NUMBER OF TURNS.

TURNS RATIO: VOLTAGE

$$\frac{E_P}{N_P} = \frac{E_S}{N_S} \quad \text{OR} \quad E_P N_S = E_S N_P \quad \text{OR} \quad E_S = \frac{E_P N_S}{N_P}$$

TURNS RATIO: CURRENT.

POWER = $P_P = E_P I_P$

$P_S = E_S I_S$.

THEN $E_P I_P = E_S I_P$

REWRITTEN - $\frac{I_P}{I_S} = \frac{E_S}{E_P}$

$\frac{E_S}{E_P} = \frac{N_S}{N_P}$ THEN $\frac{I_P}{I_S} = \frac{N_S}{N_P}$ OR $I_P = I_S\left(\frac{N_S}{N_P}\right)$

OR BEGUINING:

$N_P I_P = N_S I_S$

$\frac{I_P}{N_S} = \frac{I_S}{N_P}$ OR $I_P = \frac{I_S N_S}{N_P}$.

THE PRODUCT OF THE CURRENT TIMES THE VOLTAGE IN THE PRIMARY = THE PRODUCT OF THE CURRENT TIMES THE VOLTAGE IN THE SECONDARY. SO:

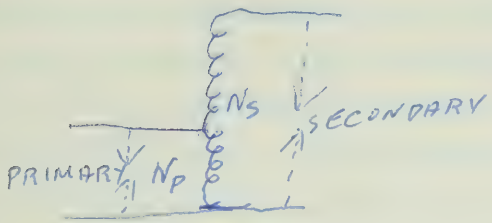
THE CURRENT ACROSS A XFORMER VARIES INVERSELY AS THE NUMBER OF TURNS

NOT IN EP

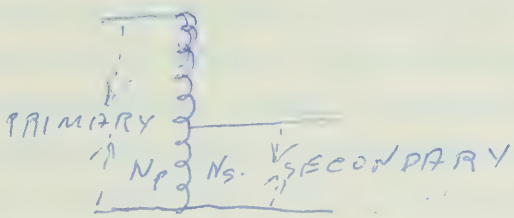
1- THE AUTOTRANSFORMER

A SPECIAL TYPE OF LOW-LOSS POWER TRANSFORMER WHICH SHOWS GOOD VOLTAGE REGULATION UNDER VARYING LOADS

IT HAS A SINGLE TAPPED WINDING



STEP UP AUTOXFORMER



STEP DOWN AUTOXFORMER.

THE RATIOS ARE THE SAME.

IN ALL XFORMERS THERE IS A 180° PHASE SHIFT IN CURRENT AND VOLTAGES.

INDUCTORS IN SERIES & PARALELL

INDUCTORS IN SERIES = $L_1 + L_2 + L_3 \cdots$

" " PARALELL $\dfrac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}} \cdots$

THESE APPLY ONLY IF THERE IS NO COUPLING OF FLUX BETWEEN THE INDUCTORS

RESISTANCE - REACTANCE - IMPEDANCE

IN D.C CKT THE ONLY OPPOSITION TO CURRENT WAS RESISTANCE. - SIMBOL "R"

IN A.C CKT THERE IS A NEW ELEMENT REACTANCE. SIMBOL X

THE TOTAL OPPOSITION TO CURRENT IT IS CALL IMPEDANCE SIMBOL - "Z"

TWO TYPES OF REACTANCE.
INDUCTIVE & CAPACITIVE.

INDUCTIVE REACTANCE:
BY REDUCING THE CEMF TO UNITS OF OPPOSITION THE OPPOSITION OFFERED BY AN INDUCTANCE TO A SINE WAVE OF VOLTAGE IS MEASURED IN OHMS AND IT IS KNOWN AS INDUCTIVE REACTANCE AND ASIGNED THE SYMBOL "X_L"
IT IS PROPORTIONAL TO THE ANGULAR VELOCITY $2\pi F$ AND THE INDUCTANCE L
$2\pi F$ (RATE OF CHANGE)

$$X_L = 2\pi FL$$

WHERE X_L IN OHMS
2π RATE OF CHANGE
F IN CYCLES
L IN HENRYS
IN AN A.C CKT THE RATE OF CHANGE OF THE CURRENT IS GOVERN BY THE ANGULAR VELOCITY OF THE APPLIED VOLTAGE, THIS VELOCITY IS MEASURED IN RADIANS. SINCE EACH CYCLE = 2π RADIANS THE ANGULAR VELOCITY = THIS FACTOR (2π) TIMES THE FREQUENCY IN CYCLES.

FROM THE FORMULA $X_L = 2\pi FL$ WE CAN SEE THAT BY INCREASIN THE FREQUENCY OR THE "L" THE X_L WILL INCREASE.
OR F↑ L↑ X_L↑

INTERPOSING. $X_L = 2\pi FL$

$$F = \frac{X_L}{2\pi L}$$

$$L = \frac{X_L}{2\pi F}.$$

CAPACITIVE REACTANCE: X_C

THE CONDUCTANCE OF A CAPACITOR TO A.C IS THE EASE WITH WHICH CURRENT FLOWS IN THE CKT AND EQUALS TO

$$G_C = 2\pi FC$$

WHERE G_C - CONDUCTANCE IN MHOS
2π - ANGULAR VELOCITY (RADIANS PER CYCLE)
F = FREQUENCY IN CYCLES
C = CAPACITANCE IN FARADS.

NOW SINCE REACTANCE IS THE OPPOSITION TO CURRENT FLOW, CAPACITIVE REACTANCE IS THE RECIPROCAL OF CAPACITIVE CONDUCTANCE "X_C"

THEREFORE $X_C = \frac{1}{2\pi FC}$ OR $\frac{1}{G_C}$

IF F OR X_C ↓

$$C = \frac{1}{2\pi F X_C}$$

$$F = \frac{1}{2\pi X_C C}$$

$$C = \frac{1}{2\pi F X_C}$$

IMPEDANCE: TOTAL OPOSITION TO CURRENT FLOW IN AN A.C. CKT. IN OHMS
SYMBO "Z"

PHASE RELATIONSHIP:
IN RESISTOR: VOLTAGE AND CURRENT IN PHASE
IN AN INDUCTOR: ELI - VOLTAGE LEADS THE CURRENT 90°
IN A CAPACITOR: ICE - CURRENT LEADS THE VOLTAGE 90°

VECTORS:

A VECTOR IS A STRAIGHT WHICH IS USED TO DENOTE THE DIRECTION AND MAGNITUD OF A GIVEN QUANTITY MAGNITUD IS DENOTED BY THE LENTH OF THE LINE WHILE DIRECTION IS INDICATED BY THE POSITION OF THE LINE WITH RESPECT TO A REFERENCE OR BASE LINE

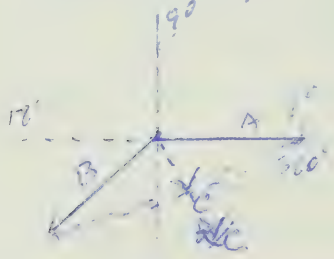
THE ENTIRE SYSTEM OF ELECTRIC CKT. ANALYSIS IS BUILT AROUND THE IDEA OF EXPRESING THE DIRECTIONS AND MAGNITUD OF VOLTAGES AND CURRENTS.

TWO OR MORE VECTORS ARE SAID TO BE EQUAL IF THEY HAVE THE SAME MAGNITUD AN DIRECTION

USE OF VECTORS - ADDITION AND SUBTRACTION

SINCE A VECTOR HAS MAGNITUD AN DIRECTION IT CAN'T BE JUST ADDED AS IN ARITHMETIC.

EXAMPLE:



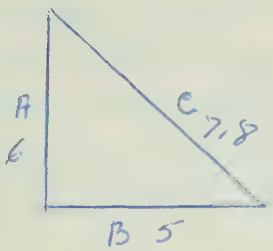
A & B ARE TWO EQUAL QUANTITIES ACTING ON DIFFERENT DIRRECTION QUANTITY "A" REPRESENTS THE REFERENCE OR BASE LINE VECTOR "C" BEING THE RESULTANT

IN ELECTRICITY THE RESULTANT VECTOR IS EXPRESED IN MAGNITUD (AMPLITUD) AN ANGLE LAGING OR LEADING THE REFERENCE VECTOR - ROTATING COUNTER CLOCKWISE.

IF TWO FORCES ACTING ON A BODY ARE AT RIGHT ANGLES TO EACH OTHER THEIR RESULTANT VECTOR MAY BE SOLVE BY GEOMETRY (PYTHAGOREAN THEOREM) OR BY TRIGONOMETRY.

SINCE IN INDUCTANCE & CAPACITANCE THERE IS A PHASE ANGLE DIFFERENCE (THEORICALLY) OF 90° DEGREES WE'LL USE THE RIGHT ANGLES ADDITION OF VECTORS

PYTHAGOREAN THEOREM STATES THAT:
IN A RIGHT TRIANGLE, THE SQURE OF THE HYPOTENUSE EQUALS THE SUM OF THE SQUARES OF THE OTHER TWO SIDES.



A = SIDE OPPOSITE
B = " ADJACENT
C = HYPOTENUSE

$$C^2 = A^2 + B^2 \quad \text{OR} =$$

$$C = \sqrt{A^2 + B^2}$$

THE $C = \sqrt{6^2 + 5^2} = \sqrt{36 + 25} = \sqrt{61} = 7.81$

THEN IF $C^2 = A^2 + B^2$

$B^2 = C^2 - A^2$

OR $A^2 = C^2 - B^2$

OR $C = \sqrt{A^2 + B^2}$

$B = \sqrt{C^2 - A^2}$

$A = \sqrt{C^2 - B^2}$

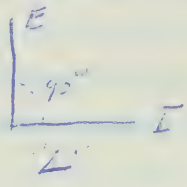
THEOREM THEN SECOND RULE: THE LENGTH OF THE HYPOTENOUS = $\sqrt{}$ OF THE SUM OF THE SQUARES OF THE OTHER TWO SIDED
AND THE LENGTH OF ANY OF THE OTHER TWO SIDES EQUALS $\sqrt{}$ OF THE DIFFERENCE OF THE HYPOTENOUS SQUARE MINUS THE OTHER SIDE SQUARE.

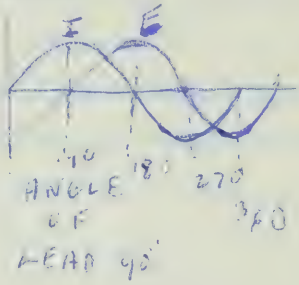
APPLYING THIS THEOREM TO SERIES L-R CKT IN A.C.

SERIES L-R CKTS.

'E' AND 'I' IN A RESISTOR IN PHASE
E AND I" IN AN INDUCTOR = "E" LEADS "I" 90°

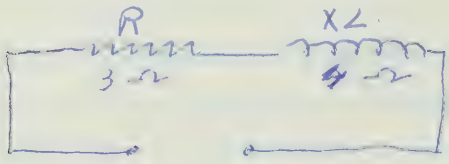
REPRESENTED VECTORIALLY





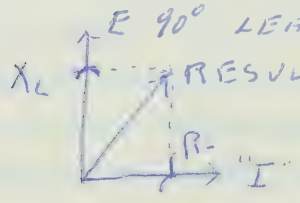
VOLTAGE AND CURRENT SINE WAVES IN AN INDUCT.

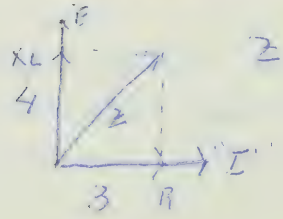
TO FIND THE IMPEDANCE (Z) OF A SERIES L-R CKT



FIND Z.

SINCE IN A SERIES CKT THE CURRENT IS COMMON TO ALL PARTS. IT IS EVIDENT THAT THE REFERENCE VECTOR SHOULD BE THE CURRENT. ALSO IN A RESISTOR THE VOLT. AND THE CURRENT ARE IN PHASE THE RESISTANCE IS PUT ~~IN~~ IN THE "I" VECTOR





$$Z = \sqrt{4^2 + 3^2} = \sqrt{16+9} = \sqrt{25} = 5$$

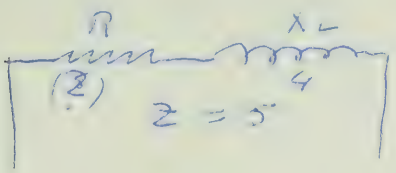
$$Z = 5$$

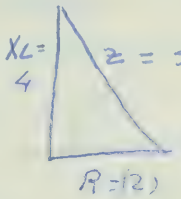
Z BEING THE HYPOTENOUSE

X_L 4 " " SIDE OPPOSITE

R 3 " " SIDE ADJACENT.

KNOWING ANY TWO SIDES OF THE RIGHT TRIANGLE ANY OF THE OTHER SIDES CAN BE FOUND





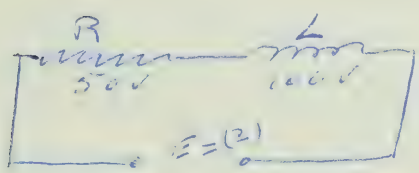
$Z = \sqrt{X_L^2 + R^2}$

$R = \sqrt{Z^2 - X_L^2}$

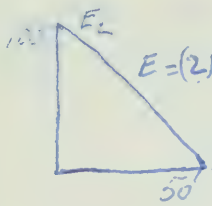
$R = \sqrt{5^2 - 4^2} = \sqrt{25-16} = \sqrt{9} = (3\,\Omega R)$

IN THIS TYPE OF CKT THE ANSWER IS INDUCTIVE BECAUSE THE RESULTANT LEADS THE REFERENCE VECTOR AND "I" WAS THE REFERENCE

TO FIND THE VOLTAGE:



(RESIST.)
USING CURRENT FOR REFER



$E = \sqrt{100^2 + 50^2} =$

$= \sqrt{10^4 + 2500} =$

$= \sqrt{1.25 \times 10^2} =$

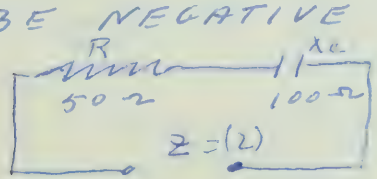
$= 10^2 \sqrt{1.25} = 111\ V.$

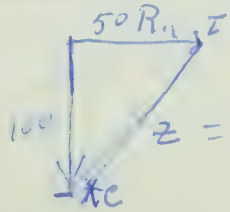
WORKING WITH VOLT. AS WITH REACTANCES ONE CAN USE THE SAME SYSTEM TO SOLVE FOR ANY OF THEM.

SERIES C - R CKT.

"E" AND "I" IN PHASE IN A RESISTOR
"E" LAGS "I" BY 90° IN A CAPCITOR (ICE)

SO TO REPRESENTE A CAPACITIVE CKT VECTORIALLY USING "I" AS REFERENCE E_C OR X_C MUST BE NEGATIVE OR BELOW THE REFERENCE LINE.



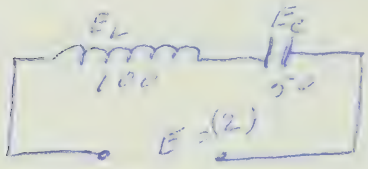


$Z = \sqrt{100^2 + 50^2} = \sqrt{1.25 \times 10^4} =$

$10^2 \sqrt{1.25} = 111\ \Omega\ Z$

IN CAPACITIVE CKT TO FIND THE Z OR ANY REACTANCE OR VOLTAGE USE THE SAME METHOD EXCEPT REPRESENT THE TRIANGLE BELOW THE REFERENCE LINE.

SERIES L-C CKT



REPRESENT L ABOVE THE LINE AND C BELOW

TO FIND THE RESULTANT ADD ALGEBRAICALY BOTH VOLTAGES.

$$+100 + (-50) = +100$$
$$\underline{\quad -50}$$
$$+50$$

THE RESULTANT VECTOR OR APPLIED VOLTAGE IS A +50 OR INDUCTIVE

THE SAME THING CAN BE DONE FOR (Z)

SERIES L-C-R CKTS.

IN A SERIER L-C-R CKT SINCE INDUCTIVE REACTANCE AND CAPACITIVE REACTANCE ARE OPOSITE, BEFORE THEY CAN BE COMBINE VECTORIALLY WITH RESISTANCE, THEIR ALGEBRAIC SUM MUST BE OBTAINED FIRST THEN TAKE THE NET IMPEDANCE. THE SAME IS DONE FOR VOLTAGES.

THUS THE GENERAL FORMULA FOR "Z" OR "E" A SERIES LCR IS

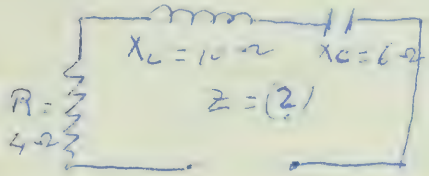
$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad \text{OR}$$
$$E_{APPLIED} = \sqrt{E_R^2 + (E_L - E_C)^2}$$

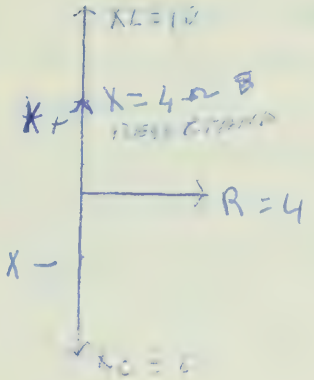
THEN $Z = \sqrt{R^2 + X^2}$ OR

$$E = \sqrt{E_R^2 + E_X^2}$$

X REPRESENTS THE NET REACTANCE. THE SIGN X^2 IS POSITIVE REGARLES IF IT IS INDUCTIVE OR CAPACITIVE BECAUSE FOR COMPUTATIONS THE SQUARE OF EITHER A PLUS OR A MINUS IS

POSITIVE. BUT IT MUST BE REMEMBER FOR THE SOLUTION MUST BE EITHER CAPACITIVE OR INDUCTIVE (+ OR −)





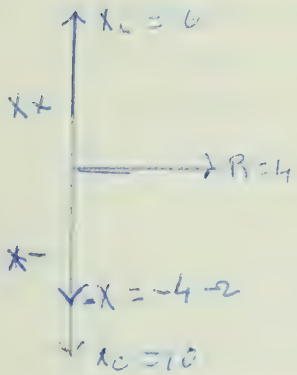
$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \Omega$$

$$= \sqrt{4^2 + (10-6)^2} =$$

$$= \sqrt{4^2 + 4^2} =$$

$$= \sqrt{32} = 5.7\ \Omega$$ INDUCTIVE

IF THE VALUES OF X_L AND X_C ARE INTERCHANGED THEN THE RESULTANT X IS A NEGATIVE 4 Ω. OR CAPACITIVE ANSWER.



$$Z = \sqrt{4^2 + (6-10)^2} \quad \text{OR} = \sqrt{4^2 + (-4^2)} \quad \text{BUT} =$$

$$= \sqrt{4^2 + 4^2} = \sqrt{32} = 5.7 \text{ CAPACITIVE.}$$

THE SAME PROCEDURE IS FOLLOW FOR VOLTAGES.

DIFFERENT PROBLEMS OF SERIES CKTS;

FIRST.

$$X_L = 2\pi FL$$

WHERE X_L = INDUCTIVE REACT.

$2\pi F = \omega$ SMALL ONIEGA OR ANGULAR VELOCITY IN RADIANS

2π RADIANS PER CYCLE.

L = INDUCTANCE IN HENRY'S

F = IN CYCLES PE SECOND

$$X_C = \frac{1}{2\pi FC}$$ X_C IS INVERSELY PROPORTIONAL TO

THE CAPACITANCE.

C = CAPACITANCE IN FARADS,

THE CURRENT THROUGH A COIL OR INDUCTANCE IS GIVEN BY

$$I_L = \frac{E_L}{X_L}$$

AND IN A CAPACITOR BY

$$I_C = \frac{E_C}{X_C}$$

THE CURRENT FLOWING IN A SERIES CKT BY

$$I = \frac{E}{Z}$$

VOLTAGE ACROSS

$R = E_R = I R$

$L = E_L = I X_L$

$C = E_C = I X_C$

$L+C = E_{L+C} = I(X_L - X_C)$

$Z = E_Z = I Z.$

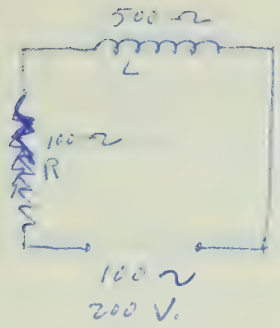
FOR L.R. SERIES CKT

$$I = \frac{E}{\sqrt{R^2 + X^2}}$$

$$E = I\sqrt{R^2 + X^2}$$

$$E^2 = I^2(R^2 + X^2) = I^2R^2 + I^2X^2 = E_R^2 + E_X^2$$

WHENCE: $E = \sqrt{E_R^2 + E_X^2}$



FIND: $L = \frac{X_L}{2\pi F} = \frac{510}{6.28 \times 100} = .78 H.$

$I_T = .39$ AMP.

$Z = 510\ \Omega$ INDUCTIVE

$E_L = IX_L = 195$ V

$E_R = IR = 39$ V.

FIRST FIND $Z = \sqrt{100^2 + 500^2} = \sqrt{26 \times 10^4} = 10^2\sqrt{26} = 510\ \Omega$

NEXT $I_T = \frac{E}{Z} = \frac{200}{570} = .39$ Amp

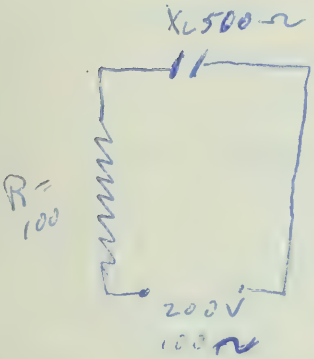
THE E_L & E_R

$E_L = IX_L = .39 \times 500 = 195$ V.

$E_R = IXR = .39 \times 100 = 39$ V.

THEN FIND L.

$X_L = 2\pi FL$; $L = \frac{X_L}{2\pi F}$ OR $\frac{510}{2\pi \times 100} = .78 H$



FIND: $C = 3$ MFD.

$I_T = .39$ AMP.

$E_C = 195$ V

$E_R = 39$ V

$Z = 510\ \Omega$ CAPACITIVE

FIND $Z = \sqrt{100^2 + 508^2} = \sqrt{26 \times 10^4} = 10^2\sqrt{26} = 510\ \Omega$

$I_T = \frac{E}{Z} = \frac{200}{510} = .39$ AMP

$E_L = .39 \times 500 = 195$

$E_R = .39 \times 100 = 39$

$X_C = \frac{1}{2\pi FC}$ $C = \frac{1}{2\pi F X_C} = \frac{1}{6.28 \times 100 \times 510} = 3$ MFD

CHARACTERISTICS OF SERIES CKTS

THE "E_T" ACROSS "R" & "L" = THE VECTORIAL SUM OF E_R & E_L

THE COMBINE RESISTANCE OF SEVERAL RESISTANCES IS THE ALGEBRAIC SUM OF ALL OF THEM

THE COMBINE REACTANCE OF SEVERAL REACTANCES WHETHER INDUCTIVE OR CAPACITIVE EQUALS THE ALGEBRAIC SUM OF ALL OF THEM.

THE IMPEDANCE OF RESISTANCES & REACTANCES IS THE VERTORIAL SUM.

THE IMPEDANCE OF SEVERAL IMPEDANCES MUST BE OBTAIN BY BREAKING DOWN THE INDIVIDUAL IMPEDANCES INTO THEIR CORRESPONDING RESISTANCES AND REACTANCES WITHOUT FORGETING THE MINUS SIGN FOR CAPACITIVE REACTANCES.

$$Z = \sqrt{(R_1 + R_2 + R_3 \cdots)^2 + (X_1 + X_2 + X_3 \cdots)^2}$$

PARALELL CKTS.

IN PARALLEL CKTS:

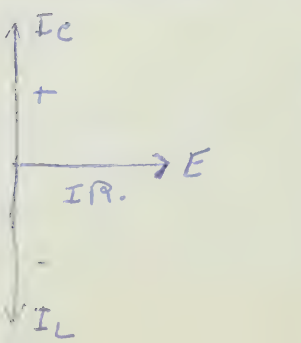
THE "E" ACROSS EACH BRANCH IS THE SAME AND IT EQUALS THE APPLIED VOLTAGE.

THE CURRENT IN ANY BRANCH EQUALS THE APPLIED "E" DIVIDED BY THE REACTANCE OR IMPEDANCE

THE TOTAL CURRENT EQUALS THE VECTORIAL SUM OF THE CURRENT IN EACH BRANCH.

THE TOTAL IMPEDANCE IS THE APPLIED VOLTAGE DIVIDED BY THE TOTAL CURRENT.

IN SOLVING PARALELL CKTS, VECTORIALLY. SINCE THE VOLTAGE IS COMMON TO ALL BRANCHES THE REFERENCE VECTOR MUST BE THE VOLTAGE AND DRAW THE OTHER VECTOR IN TERMS OF CURRENT LEADING OR LAGGING.

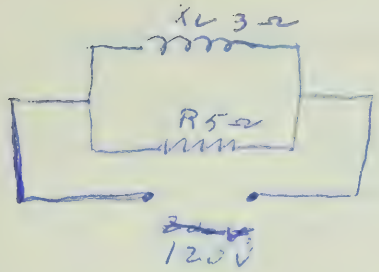


IN TERMS OF CURRENT

I LEADS "E" IN A CAP. 90° SO IS PLUS

I LAGGS "E" " " INDUC. 90° SO IS MINUS

I IN PHASE WITH E IN A RESISTOR.



FIND: $Z = 2.6\ \Omega$

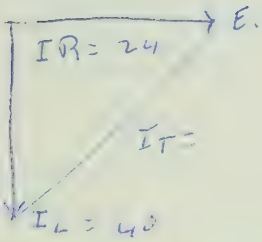
$I_R = 24$ AMP

$I_L = 40$ AMP

$I_T = 46.7$ AMP INDUCTIVE (LAGG.)

FIRST $I_L = \frac{E}{X_L} = \frac{120\ V}{3\ \Omega} = 40$ AMP (INDUCTOR)

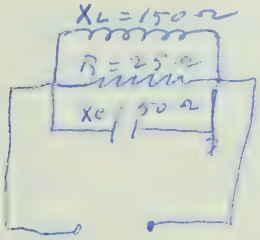
THEN $I_R = \frac{E}{R} = \frac{120}{5} = 24$ AM (RESISTOR)



$I_T = \sqrt{40^2 + 24^2} = \sqrt{2136} = 46.2$ AMP

$Z = \frac{E}{I_T} = \frac{120}{46.7} = 2.6\ \Omega$

TO FIND THE IMPEDANCE OF PARALLEL CKT WHERE THE APPLIED VOLTAGE IS NOT GIVEN ONE CAN ASSUME ANY VOLTAGE AND SOLVE FOR THE INDIVIDUAL CURRENTS. THESE CURRENTS THEN ARE ADDED VECTORIALLY TO FIND THE TOTAL CURRENT. THEN THE ASSUMED VOLTAGE IS DIVIDED BY THE TOTAL CURRENT TO FIND THE Z OF THE CKT. THE ASSUMED VOLTAGE SHOULD BE A POWER OF TEN FOR EASIEST WORK AND IT SHOULD BE GREATER THAN THE LARGEST REACTANCE OR IMPEDANCE.



FIND $Z = \frac{1000}{42.4} = 23.5\ \Omega$

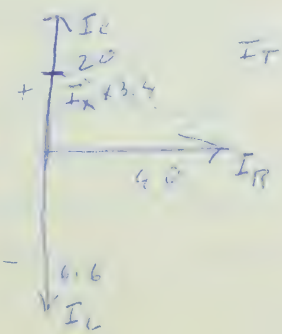
$I_T = 42.4$ AMPS.

FIRST WE ASUME AN APPLIED VOLTAGE 1000 V.

$I_L = \frac{1000}{150}$ 6.6 AMP

$I_R = \frac{1000}{25} = 40$ AMP.

$I_C = \frac{1000}{50} = 20$ AMP



$I_T = \sqrt{40^2 + (20 - 6.6)^2} =$

$= \sqrt{1600 + 179} =$

$= \sqrt{1779} = 42.2$ AMP

SOLVING A.C. PROBLEMS BY TRIG.

RIGHT TRIANGLES

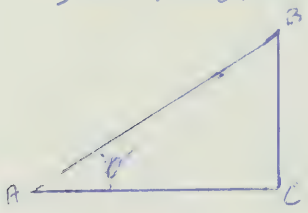
IF ONE OF THE ANGLES OF A TRIANGLE IS A RIGHT ANGLE THE TRIANGLE IS CALLED RIGHT TRIANGLE

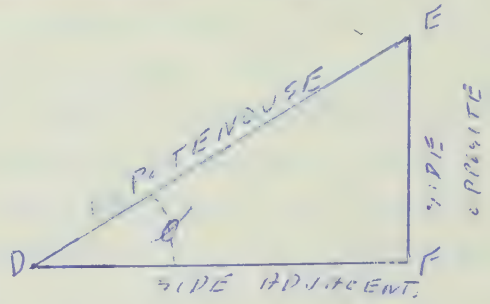
RULE → THE SUM OF THE ANGLES IN A TRIANGLE = 180°

A RIGHT TRIANGLE HAS A RIGH ANGLE 90°. THEREFORE. THE SUM OF THE OTHE TWO ANGLES MUST BE 90°. THIS ENABLES TO FIND ONE ACUTE ANGLE IF THE OTHER IS GIVEN.

SINCE ALL RIGHT ANGLES ARE EQUAL, THEREFORE IF AN ACUTE ANGLE EQUAL OF ONE RIGHT TRIANGLE IS EQUAL TO ANOTHER ACUTE ANGLE IN ANOTHER RIGHT TRIANGLE BOTH TRIANGLES ARE EQUAL

SO THEN:





SINCE THE ACUTE ANGLE θ IS EQUAL IN BOTH RIGHT TRIANGLES BOTH ARE EQUAL.
GEOMETRY PROVES THAT THE RATIO OF SIDE "AB" TO SIDE "AC" EQUALS THE RATIO OF SIDE "DE" TO SIDE "DF" THAT IS:

$$\frac{\text{HYPOTENOUSE}}{\text{ADJACENT}} = \frac{AB}{AC} = \frac{DE}{DF}$$

THIS SHOWS THAT THE DIFFERENCE IN SIZES OF THE RIGHT TRIANGLES HAS NO EFFECT ON THE RATIOS IF THE ACUTE θ ANGE IS THE SAME.

→ THIS RATIO HAS THE SAME VALUE FOR ALL RIGHT TRIANGLES WITH A GIVEN ACUTE ANGLE θ AS THE ADJACENT ANGLE.

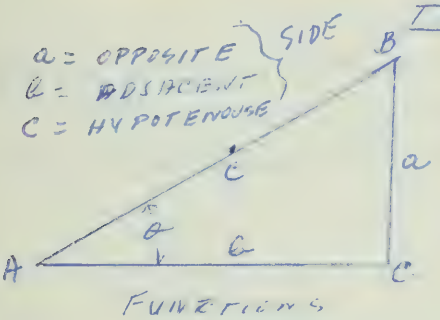
THEREFORE THE FOLLOWING LAW IS EVIDENT:

LAW →: THE RATIO OF ANY TWO SIDES OF A RIGHT TRIANGLE WITH θ AS ONE ACUTE ANGLE, DEPENDS ONLY ON THE SIZE OF THE ANGLE AND NOT ON THE SIZE OF THE TRIANGLE.

EXAMPLE: IF THE RATIO OF THE OPPOSITE SIDE TO THE ADJACENT SIDE IS 2 - THE ANGLE WILL BE THE SAME FOR ANY TWO OPPOSITE & ADJACENT SIDED WHOS RATIO IS TWO.

THE LAW STATES THAT: THE RATIO OF ANY TWO SIDES IS A FUNCTION OF THE ACUTE θ ANGLE.

THE SIX POSSIBLE RATIOS ARE CALLED THE TRIGONOMETRIC FUNCTIONS



FUNCTIONS

NAMES OF FUNCTIONS

θ = ACUTE ANGLE

BC = LINE FROM B TO C TO FORM THE RIGHT TRIANGLE WITH THE ANGLE θ

THE SMALL LETTERS REPRESENT THE LENGTHS OF THE SIDES: REFERING TO THE DIAGRAM WE GIVE NAMES, RATIOS AND ABBREVIATIONS OF THE SIX FUNCTIONS:

RATIO	NAME	ABBREVIATIONS.
$\frac{a}{b}$	TANGENT OF θ	TAN θ
$\frac{a}{c}$	SINE OF θ	SIN θ
$\frac{b}{c}$	COSINE OF θ	COS θ
$\frac{b}{a}$	COTANGENT OF θ	COT θ
$\frac{c}{b}$	SECANT OF θ	SEC θ
$\frac{c}{a}$	COSECANT OF θ	CSC θ

OF THESE SIX FUNCTIONS THE THREE MOST IMPORTANT ARE

REMEMBER THESE →

TANGENT OF θ = $\frac{\text{SIDE OPPOSITE}}{\text{SIDE ADJACENT}}$

SINE OF θ = $\frac{\text{SIDE OPPOSITE}}{\text{HYPOTENOUSE}}$

COSINE OF θ = $\frac{\text{SIDE ADJACENT}}{\text{HYPOTENOUSE.}}$

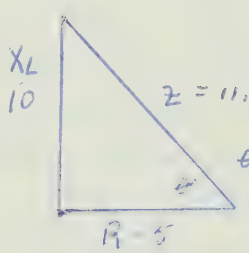
THESE THREE FUNCTIONS ARE THE ONES WE'LL USE

SOLVING A.C PROBLEMS BY TRIG FUNCTIONS!

~~ONE FUNCTION GIVEN~~ :

THE FUNCTIONS OF AN ANGLE ARE GIVEN IN THE TABLES OF NATURAL FUNCTIONS.
TM-682 LOOKS UP TO 90° IN TM-681 UP TO 45°

EXAMPLE 1: ONE FUNCTION GIVE



FIND Z = FUNCTION GIVEN:

TANGENT $\frac{\text{OPPOSITE}}{\text{ADJACENT}}$ OR $\frac{10}{5} = 2$

LOOK IN TABLE FOR THE TANGENT 2 AND FIND ANGLE 63.5°

NOW:

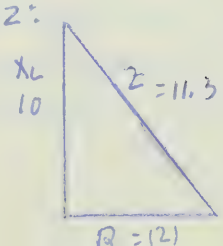
SINE FUNCTION OF 63.5° = .8949 (IN TABLE)

SO SINE OF 63.5 = $\frac{\text{OPPOSITE}}{\text{HYPOTEN.}}$ OR $\frac{10}{Z} = .8949$ (.895

THEN $Z = \frac{10}{.895} = 11.3\ \Omega$

NOTE- SINE FUNCTIONS ARE FROM 0 TO 1

EXAMPLE 2:



FIND R = FUNCTION GIVE = SINE = $\frac{\text{OPPOSITE}}{\text{HYPO}}$ =

$= \frac{10}{11.3} = .895$-

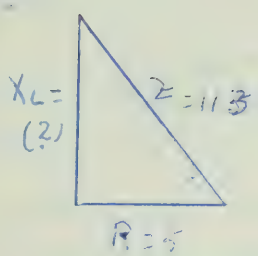
NEXT FIND IN TABE ANGLE FOR SINE OF .895

SINE OF .895 = 63.5°

NEXT FIND THE TANGENT FOR 63.5° = $\frac{\text{OPPOSITE}}{\text{ADJACENT}}$

OR $\frac{10}{R} = 2$ THEN $R = \frac{10}{2} = 5$

EXAMPLE 3:



FUNCTION GIVEN: COSINE = $\frac{\text{ADJACENT}}{\text{HYPOTENUSE}}$

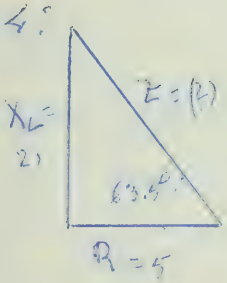
OR $\frac{5}{11.3} = .4424$

NEX LOOK FOR THE ANGLE OF COSINE .4424 WHICH IS 63.5°

NEX FIND THE TANGENT OF 63.5° = 2

SO TANGENT = $\frac{\text{OPP}}{\text{ADJ}} = \frac{X_L}{5} = 2$ OR $X_L = 2 \times 5 = 10\ \Omega$

EXAMPLE 4:



TWO WAYS OF SOLVING THIS ONE

FIRST TANGENT = $\frac{\text{OPP}}{\text{ADJ.}}$ OF 63.5° = 2

SO $\frac{X_L}{5} = 2$ THEREFORE $X_L = 5 \times 2 = 10$

NOW SINE OF 63.5° = .895 = $\frac{\text{OPP}}{\text{HYP}}$ OR $\frac{10}{Z}$

$Z = \frac{10}{.895} = 11.3$

SECOND: COSINE $\frac{\text{ADJ}}{\text{HYP}}$ OF 63.5 = .442 = $\frac{5}{Z} = .442$

OR $Z = \frac{5}{.442} = 11.3$ NOW WE CAN PROCEED WITH EITHER THE TANGENT OR THE SINE

IF ANY TWO FUNCTIONS ARE GIVEN ALL THE OTHER FUNCTIONS CAN BE FOUND!

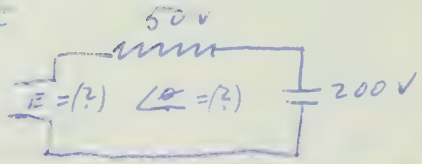
RULES → THE TANGENT FUNCTION GIVES THE RESULTANT VECTOR ~~X~~ R

THE SINE FUNCTION GIVES THE REACTIVE VALUES WITH RESPECT TO THE RESULTANT VECTOR: $\frac{X}{Z}$

THE COSINE FUNCTION GIVES THE RESISTIVE COMPONENT $\frac{R}{Z}$

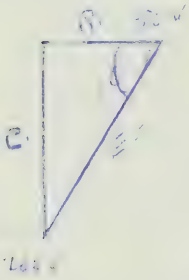
APLICATIONS OF TRIG FUNCTIONS TO SERIES A.C. PROBLEMS (CKTS)

EXAMPLE 1.



FIND E= AND THE ANGLE OF LEAD OR LAG = −72°

FIRS SET UP THE TRIANGLE AND FIND THE ANGLE



Tangent $\theta = \frac{200}{50} \cdot 4 = -76°$ FOUND IN TABLE

MINUS BECAUSE "ICE" T-F CAP. VOLTAGE LAGS THE CURRENT

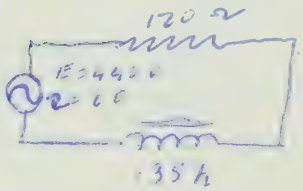
NEXT SINE $-72° = .970$ OR $\frac{200}{E} = .970$

$\therefore E = \frac{200}{.970} = 206$ V. SO THE ANSWER WOULD BE WRITTEN:

$E = 206 \angle -76$ V.

THE SAME PROCESS WOULD BE FOLLOW TO FIND THE Z IF THE X WERE GIVEN.

EXAMPLE 2



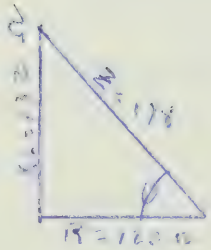
FIND: $\theta = 47.7°$
$Z = 178$
$I = 2.47$
$X_L = 132\ \Omega$
$E_L = 335$ V
$E_R = 293.5$ V.

IN THIS TYPE OF PROBLEM WE CAN FIND MORE THAN ABOUT A CKT

FIRST LETS FIND $X_L = \omega L = 6.28 \times 60 \times .35 = 132\ \Omega$

NEXT WE DRAW THE VECTOR DIAG: NOW THEN $\tan \theta = \frac{X_L}{R} = \frac{132}{120} = 1.10$

$\therefore \theta = 47.7°$



Now $Z = \frac{X_L}{\sin \theta} = \frac{132}{.477} = 178$ $\left(\sin \theta = \frac{X_L}{Z}\right)$

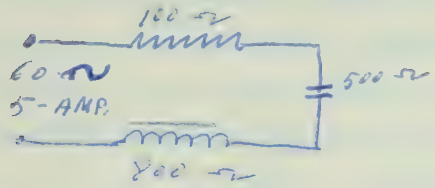
OR $Z = \frac{R}{\cos \theta} = \frac{120}{.213} = 178\ \Omega$

THEN $I = \frac{E}{Z} = \frac{440}{178} = 2.47$ a.

$E_L = X_L I = 132 \times 2.47 = 335$ V.

$E = R I = 120 \times 2.47 = 293.5$ V

APLICATIONS TO COMBINATIONS L.C.R SERIES



FIND: $\theta = 71.6°$

$E_T =$ ~~1580~~ 1580 V.

$Z =$ ~~316~~ 316 Ω

$C = 53$ MFD

$L = 21.3$ HENRY'S.

$E_R = 100 \times 5 = 500$ V

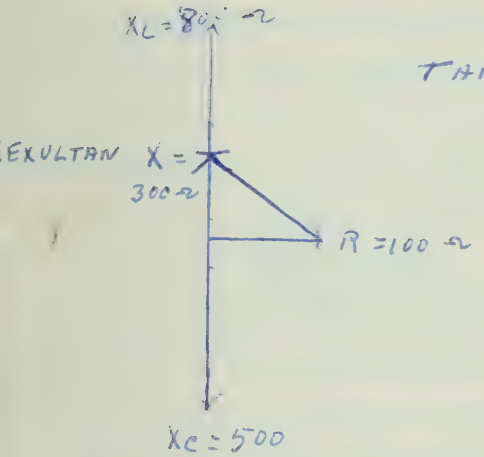
$E_C = 500 \times 5 = 2500$ V

$E_L = 800 \times 5 = 4000$ V.

$$L = \frac{X_L}{\omega} = \frac{800}{\omega} = \frac{800}{37.58} = 21.3$$

$$C = \frac{1}{\omega X_C} = \frac{1}{37.68 \times 500} = \frac{1}{1.88 \times 10^4} = 53 \text{ MFD}$$

NEXT SET THE VECTOR DIAGRAM IT CAN BE DONE BY USING THE VOLTAGES OR THE IMPEDANCES.



$$\text{TAN } \theta = \frac{300}{100} = 3 \quad \therefore 71.6°$$

$$Z = \frac{X_L}{\text{SINE } \theta} = \frac{300}{.949} = \text{~~316~~ } 316\ \Omega$$

$$E_T = IZ \text{ OR } \frac{316}{\text{~~316~~}} \times 5 = 1580 \text{ V}$$

$$E = 1580 \angle 71.6° \text{ V}$$

$$Z = 316 \angle 71.6° \ \Omega.$$

CHARACTERISTICS OF ~~FORMULAS~~ ~~TEST~~ SERIES CKTS.

1. IN A SERIES CKT THE CURRENT EITHER LEADS OR LAGS THE APPLIED VOLTAGE DEPENDING ON WHETHER X_C IS GREATER THAN OR LESS THAN X_L.

L-R CKT
2. THE I IN AN INDUCT. LAGS THE "E" BY 90°
3. THE "E" ACROS "R" IS 90° OUT OF PHASE WITH THE "E" IN "L"
4. THE RESULTANT VOLTAGE IS THE VECTOR SUM AND ALSO IS EQUAL TO THE APPLIED. (KIRCHHOFF'S LAW)
5. THE CURRENT IN THE CKT LAGS THE VOLTAGE BY $\angle\theta$ (PHASE ANGLE) USUALLY LESS THAN 90°

SERIES ↓ -R.

THE "I" IN A CAP. LEADS "E" BY 90°

THE "E" IS 90° OUT OF PHASE WITH THE ER. THE RESULTANT AL SO IS THE APLIED. THE "I" IN A C-R SERIES LEADS THE VOLTAGE BY $\angle\theta$ USUALLY LESS THAN 90°

-R

TS.

SERIES
L-C-R → THE NET REACTANCE OF AN L-C-R SERIES CKT IS THE ALGEBRAIC SUM OF BOTH REACTANCES X_L Y X_L. THE THE TOTAL Z WILL BE FOUND BY TREATING THE CKT AS IF IT WAS STRICTLY - INDUCTIVE OR CAPACITIVE, DEPENDING ON WHETHER X_L OR X_C IS LARGER.

THEREFORE THE CURRENT WILL LAG OR LEAD THE VOLTAGE DEPENDING ON WHETHER X_L OR X_C IS LARGER.

THE VOLTAGE ACROSS A REACTIVE ELEMENT CAN BE LARGER THAN THE APPLIED VOLTAGE.

NOTATIONS FOR SERIES CKTS
COOKS PAGE 332-33.

MECHANICS OF POSITIVE AND NEGATIVE "J" OPERATOR

THE J OPERATOR IS REPRESENTED AS A LINE DRAWN 90° FROM THE LINE USED TO REPRESENT POSITIVE AND NEGATIVE NUMBERS.

THE HORIZONTAL LINE IS CALLED THE AXIS OF REAL NUMBERS

THE VERTICAL LINE ON WICH WE PLOT NUMBERS HAVING +J OR -J AS A COEFICIENT IS CALLED THE AXIS OF IMAGINARY NUMBERS.

THE +J NUMBERS ARE LEADING THE REFERENCE LINE
" -J " " " LAGING " " " "
AND ANY NUMBER WITH A + OR - J PREFIX MEANS THAT IT IS ROTATING THROUGH AN ANGLE OF 90° AND IT IS EITHER LEADING OR LAGING THE REFERENCE LINE.

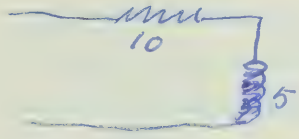
NOW THEN WE CAN REPRESENT SERIES L-C-R CKT WITH THIS KIND OF NOTATIONS.

WE CAN REPRESENT THE RESISTANCE VECTOR AS A REAL NUMBER ON THE HORIZONTAL LINE. AND SINCE REACTANCES ARE DISPLACED 90° FROM RESISTANCE ON A VECTOR DIAGRAM, IT FOLLOWS THAT INDUCTIVE REACTANCE CAN BE PREFIXED WITH +J FACTOR AND CAPACITANCE REACTANCE WITH A −J.

NOW WE HAVE ANOTHER FORM REPRESENTING A SERIES CKT.
IT IS CALLED RECTANGULAR FORM

R = REAL NUMBER. $X_L = +J$; $X_C = -J$

EXAMPLE:



R-LCKT IN RECTANGULAR FORM =

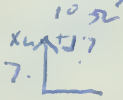
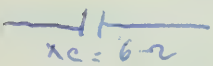
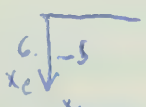
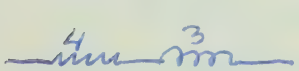
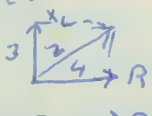
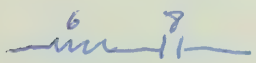
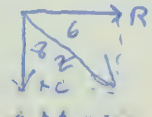
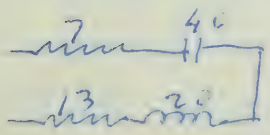
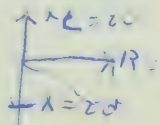
$$Z = 10 + J5\ \Omega$$

ANOTHER FORM OR NOTATION IS THE POLAR FORM: THIS FORM INDICATES IF THE CKT IS INDUCTIVE OF CAPACITIVE SINCE THE θ IS REPRESENTED + OR −

EXAMPLE:

$= Z = 10 \angle -53.1^\circ\ \Omega$. SINCE THE θ IS − THE CKT IS CAPACITIVE.

THREE TYPE OF NOTATIONS FOR SERIES CKTS:

CKT	VECTOR	RECTANGULAR	POLAR
		$Z = 10 + J0\ \Omega$	$Z = 10 \angle 0^\circ\ \Omega$
		$Z = 0 + J7\ \Omega$	$Z = 7 \angle 90^\circ\ \Omega$
		$Z = 0 - J6\ \Omega$	$Z = 6 \angle -90^\circ\ \Omega$
		$Z = 4 + J3\ \Omega$	$Z = 5 \angle 36.9^\circ\ \Omega$
		$Z = 6 - J8\ \Omega$	$Z = 10 \angle -53.1^\circ\ \Omega$
		$Z = 20 - J20\ \Omega$	$Z = 28.2 \angle -45^\circ$

NOTE THAT THE SIGN OF THE θ IS THE SAME AS THE J FACTOR.
THE RECTANGULAR OR THE POLAR FOR ONLY REPRESENT CKT CONDITIONS

CONVERSION FROM RECTANGULAR FORM TO POLAR AND VICEVERSA

EXAMPLE: SOLVE FOR Z IN $250 - J100\ \Omega$

$Z = R - JX = 250 - J100\ \Omega$

$\tan \theta = \frac{100}{250} = .4 \quad \therefore \quad .4 = -21.8°$

(SINE) $Z = \frac{X}{\sin\theta} = \frac{100}{\sin -21.8°} = 269\ \Omega$: SO POLAR $Z = 269 \angle -21.8°$

NOW SOLVE FOR $Z = 269 \angle -21.8°$ IN RECTANGU.

FIRST FIND COSINE $= \frac{ADJ}{HY}$ OR $\frac{R}{269}$

$\cos 21.8° = \frac{R}{269} = .9285$; $R = 269 \times .9285 = 250$

SINE $21.8° = \frac{X}{269} = .3714$; $X = .3714 \times 269 = 100\ \Omega$

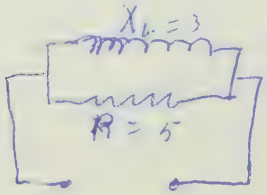
OR $Z = 100 - J250$ OR

$Z = 269 \cos 21.8° - J269 \sin 21.8° = 250 - J100\ \Omega$

PARALELL CKTS

TO SOLVE PARALELL CKTS BY TRIG. THE SAME THINGS HOLD TRUE THAN WHEN SOLVING THEM BY PYTHAGORRAS THEOREM. SINCE THE VOLTAGE IS THE SAME IN ALL BRANCHES IT MUST BE USED AS THE REFERENCE VECTOR. AND THE OTHER VECTORS MUST BE THE CURRENT WITH REFERENCE TO THE VOLTAGE, LAGING OR LEADING.

EXAMPLE: 1



$Z =$

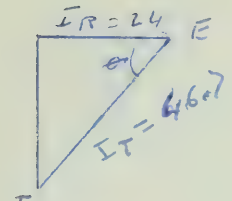
FIRST FIND I_L & I_R

$I_L = 120 \div 3 = 40$ AMP

$I_R = 120 \div 5 = 24$ AMP

VECTORS →

"E" MUST BE THE REFERENCE VECTOR



$\tan\theta = \frac{OP}{AD} = \frac{40}{24} = 1.75 = \theta = 60.3°$

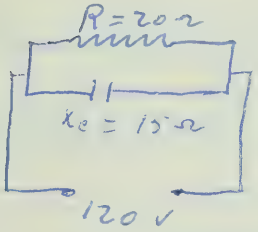
$\text{SINE}\ \theta = \frac{OP}{HY} = \text{SINE}\ 60.3° = .8670 = \frac{40}{IT}$

$IT = \frac{40}{.8670} = 46.7$

IN POLAR NOTATION = $46.7 \angle -60.3°$

NOW $Z = \frac{120}{46.7} = 2.6\ \Omega$

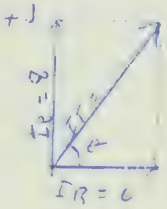
EXAMPLE 2



FIND Z =

FIRST $I_R = \frac{120}{20} = 6$ A.

$I_C = \frac{120}{15} = 8$ A



BY RECTANGULAR NOTATION $I_C = 0 + J8$ A.

$+ \quad I_R = 6 + J0$ A.

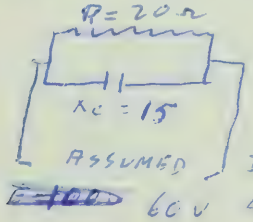
$I_T = 6 + J8$ A

$\tan\theta = \frac{8}{6}\ 1.332 \quad \theta = +53.1° \quad \text{SINE}\ +53.1° = .7997 = \frac{8}{IT}$

$IT = \frac{8}{.7997} = 10$ A $\quad IT = 10 \angle 53.1°$ A.

$Z = \frac{120}{10} = 12\ \Omega$ OR $12 \angle -53.1°$

EXAMPLE 3. TO FIND Z IF THE VOLTAGE IS NOT GIVEN. ONE MAY ASSUME A VOLTAGE AND SOLVE FOR THE INDIVIDUAL I_S



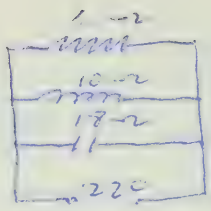
$I_R = \frac{60}{20} = 3$ a $\quad I_C = 60 \div 15 = 4$ a

$\tan\theta = \frac{4}{3} = 1.332\ \theta = +53.1°$

$\text{SINE}\ 53.1° = .7997\ \frac{4}{IT} = IT = \frac{4}{.7997} = \frac{5}{}$ A.

$Z = \frac{60}{5} = 12\ \Omega$ SAME RESULT

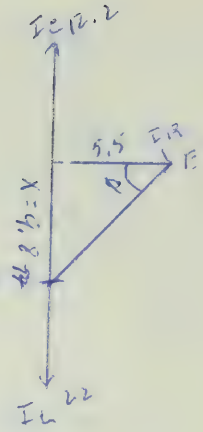
EXAMPLE 4



$I_R = \frac{220}{40} = 5.5\ A$

$I_L = \frac{220}{10} = 22\ A$

$I_C = \frac{220}{17} = 12.2\ A$



12.2 − 22 = −9.8 ALGEBRAIC SUM

ADDING VECTORIALLY

$I_R = 5.5 + J0\ A$

$I_C = 0 + J12.2\ A$

$I_L = 0 - J22\ A$

$I_T = 5.5 - J9.8\ A.$

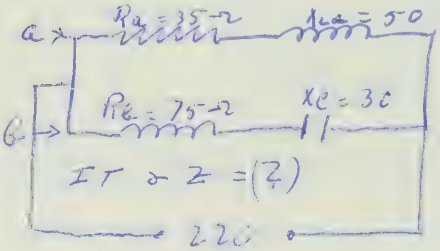
SOLVING FOR IT: TANG. $\theta = \frac{9.8}{5.5} = 1.782$ $\theta = -60.7°$

$\sin -60.7° = .8721 = \frac{9.8}{IT} = IT = \frac{9.8}{.8721} =$

$= IT = 11.2\ a$ OR $11.2 \angle -60.7°\ A.$

$Z = \frac{220}{11.2} = 19.6\ \Omega$ OR $Z = 19.6 \angle 60.2°$

EXAMPLE 5 SERIES PARALELL; COMPLEX CKTS.



FIRST SOLVE FOR I_a AND I_b

$Z_a = 35 + J50\ \Omega = 61 \angle 55°$

$Z_b = 75 - J30\ \Omega =$

CONVERT THIS RECTANGULAR FORMS TO POLAR

$I_a = 3.61\ A$ $Z_a = \tan \theta = \frac{50}{35} = 1.428$ @ 55° $\sin = \frac{50}{Z_a} = .8192$ $I_a = \frac{50}{.8192} =$

$I_b = 2.72\ A$ $= 61\ \Omega$

$Z_a = 61 \angle 55°\ \Omega$

$Z_b = 80.8 \angle -21.8°$

$Z_b = \tan a \frac{30}{75} = .4000$ @ 21.8° $\sin = .3714$

$\sin .3714 = \frac{30}{Z_b}$ $Z_b = \frac{30}{.3714} = 80.8 \angle -21.8°$

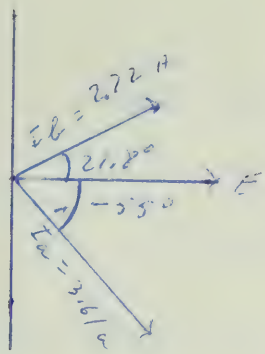
NEXT: SOLVE FOR I_a & I_b

$I_a = \frac{220}{61} = 3.61\ A$ $I_b = \frac{220}{80.8} = 2.72\ A$

CURRENT VECTORS

$Z_a = 61 \angle -55^\circ \Omega$ ∴ $I_a = 3.61 \angle -55^\circ$ A.

$Z_b = 80.8 \angle -21.8^\circ \Omega$ ∴ $I_b = 2.72 \angle 21.8^\circ$

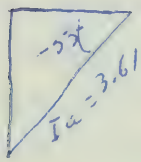


TO FIND THE TOTAL Z WE MUST FIND THE TOTAL I BUT I_a & I_b MUST BE ADDED VECTORIALLY BECAUSE THEY CONTAIN RESISTIVE AND REACTIVE COMPONENTS

TO DO THIS THEY MUST BE CONVERTED FROM POLAR TO RECTANGULAR FORM

CONVERTING FROM POLAR FORM, IN WHICH THE ANGLE & MAGNITUD ARE GIVEN, TO RECTANGULAR FORM IS SIMPLIFIED BY USING TRIG FUNTIONS

$I_a = 3.61 \angle -55^\circ$ A.



COSINE $-55 = \frac{AD}{3.61} = .5736$ ∴ $AD = 3.61 \times .5736 = +2.07$

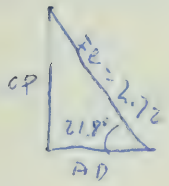
SIN $-55 = \frac{OP}{3.61} = .8192$ ∴ $OP = 3.61 \times .8192 = -2.96$

SINCE THE −55 IN IN THE FOURTH QUADRANT THE SINE IS − AND THE COS IS +.

IR- 2.07 ≠ I_a

SO I_a RECTANGULAR - = $2.07 - J2.96$ Ω.

FOR $I_b = 2.72 \angle 21.8^\circ$



$\cos 21.8^\circ = \frac{AD}{2.72} = .9285$ ∴ $AD = 2.72 \times .9285 = 2.53$ A

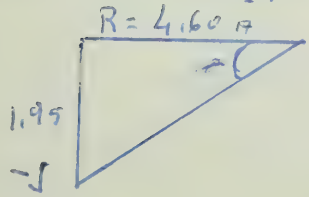
$\sin 21.8 = \frac{OP}{2.72} = .3714$ ∴ $OP = 2.72 \times .3714 = 1.01$ Ω.

IN RECTANGULAR FORM $I_b = 2.53 + J1.01$ A.

$I_T = I_a = 2.07 - J2.96$ A

$I_b = 2.53 + J1.01$ A

$I_T = 4.60 - J1.95$ A



SOLVING VECTORIALLY :

TAN $\theta = \frac{1.95}{4.60} = .424$ $\theta = -23^\circ$

SIN $-23^\circ = \frac{1.95}{IT} = .3907$ ∴ $IT = \frac{1.95}{.3907} = 5.$

$I_T = 4.60 - j1.95 = 5. \angle -23^\circ$

$Z_T = \frac{E}{I_T} = \frac{220}{5} = 44\ \Omega$ OR $Z_T = 44 \angle 23^\circ$

CHARACTERISTICS OF PARALLEL CKTS

1 IN A L-R PARALLEL CKT. THE "E" IS EQUAL IN BOTH BRANCHES

2 THE BRANCH CURRENTS ARE 90° OUT OF PHASE WITH I_L LAGING.

3 IN A R-C CKT - THE "E"s ARE EQUAL

4 THE BRANCH "I" ARE 90° OUT OF PHASE WITH I_C LEADING.

5 IN A L-C CKT IF X_L is GREATER THAN X_C THEN I_C IS GREATER THAN I_L, THE CKT ACTS CAPACITIVE AND LINE CURRENT LEADS THE APPLIED VOLTAGE. IF X_C IS GREATER THAN X_L THEN I_L IS GREATER THAN I_C AND THE CKT ACTS INDUCTIVE, THE LINE CURRENT LAGS THE APPLIED VOLTAGE.

6 IN A L-C-R CKT NOT AT RESONANCE IS EITHER A PARALLEL L-R OR C-R DEPENDING ON WHETHER I_C OR I_L IS GREATER

7 ALSO IN A PARALLEL L-C-R THE TOTAL Z MAY BE LARGER THAN THE SMALLEST REACTANCE.

8 THE CURRENT THROUGH ANY BRANCH EQUALS THE APPLIED "E" DIVIDED BY THE REACTANCE.

9 THE TOTAL CURRENT IS THE VECTOR SUM.

10 THE TOTAL Z EQUALS THE APPLIED "E" DIVIDED BY I_T.

PROCEDURE IN SOLVING COMPLEX R.C CKTS (SERIES PARALLEL) BY THE TOTAL CURRENT METHOD

1 DRAW A SIMPLIFIED CKT DIAGRAM OF THE CKT

2 LABEL ALL THE KNOWN VALUES

3 FIND THE VECTOR IMPEDANCE (POLAR FORM) OF EACH PARALLEL BRANCH

IMPROVING THE LOUDSPEAK.

~~FOLDED HOR~~

LOW FR. REQUIREMENTS.

1- SUFFICIENT POWER. NEED TO MOVE MORE AIR.

2- LARGE SURFACE AREA.

3- CONE FLEXIBLE - LARGE MOVEMENT.

HIGH FR. REQUIREMENTS.

1 - LESS POWER

2 - LOW MASS OR SURFACE AREA

3 - RIGIDITY OF THE CONE. (STIFF)

BAFLES. IS NECESSARY TO INSTALL THE SPEAKER IN THE CENTER OF A LARGE BAFFLE TO PREVENT THE BACK WAVES FROM CANCELLING THE FRONT WAVES. IT SHOULD BE GREAT ENOUGH SO THAT THE SHORTEST MECHANICAL LENTH BETWEEN FRONT AND BACK IS AT LEAST ONE QUATER WAVE-LENTH FOR THE LOWEST NOTE.

AT LOW FREQ. THE COUPLING BETWEEN THE CONE AND AIR IS LOW ABOUT 10%.

FOLDED HORN. COMPRESSES WAVES AT LOW FR. FOR BETTER AND MORE EFFICIENT REPRODUCTION.

INFINITE BAFFLE, NO WAVES GET TO THE FRONT FROM THE BACK

BASS REFLEX; IT CONTAINS LABYRINTHS INSIDE THE ENCLOSURE TO MAKE THE DISTANCE LONGER FOR THE BACK WAVES TO TRAVEL TO THE PORT-HOLES AND COME OUT IN PHASE. THIS ADDS TO THE LOW FR. BY AS MUCH AS 10 db. THE HIGH FR. ARE DAMPED BY LINING THE INSIDE WITH AB-SORPTIVE MATERIAL.

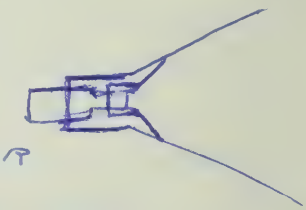
WHEN A WIDE RANGE OF FR. MUST BE REPRODUCE TWO SPEAKERS ARE USED.

ALSO COAXIAL SPEAKES : TWO IN ONE

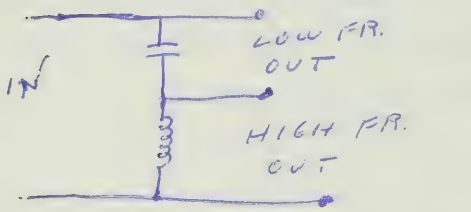
BY MAKING A CONE FLEXIBLE AT THE ENDS THE LOWS CAN BE REPRODUCED.
BY MAKING THE CONE RIGID BY CORRUGATION AT THE BOTTOM THE HIGHS CAN BE REPRODUCED

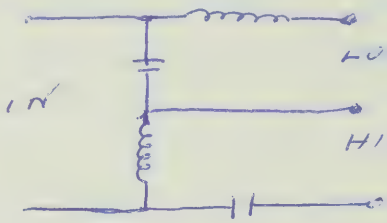
COAXIAL SPEAKERS. TWO VOICE COIL, TWO CONES.

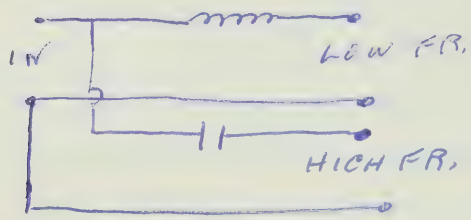
TWEETER FOR HIGHS INSIDE AND WOOFER FOR LOWS OUTSIDE

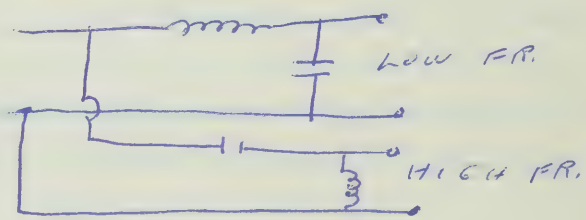


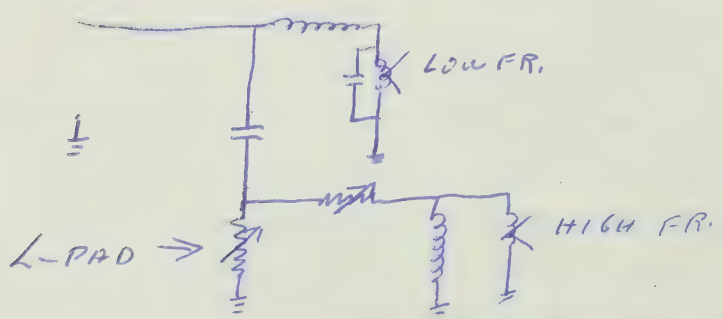
TO FEED THE DIFFERENT FR. TO THEIR OWN CONE.
CROSS OVER NETWORKS: OR L PADS.

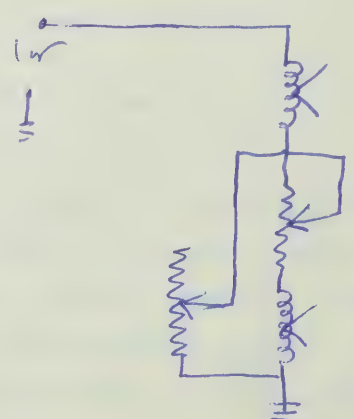




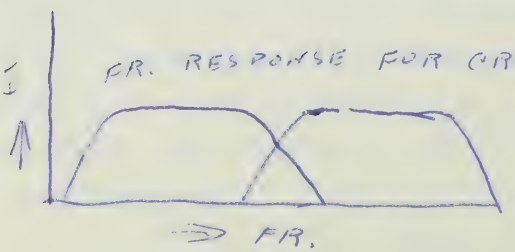








L-PAD TO VARY THE VOLUME OF A DIFFENT SPEAKER WHEN THERE IS MORE THAN ONE



PICK-UPS AND RECORDS!

VERTICAL RECORDINGS - OLD - NOT GOOD

LATERAL RECORDINGS. THE QUALITY VARIES TOWARS THE CENTER SINCE THE VELOCITY OF THE NEEDLE WILL INCREASE. SHORTER GROOVES.

CONSTANT AMPLITUD AND CONSTANT VELOCITY OF THE NEEDLE IS USED. IN RECORDINGS.

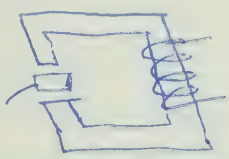
78 RPM 100 LINES P.INCH.

MICROGROVE 200-300 LINES PER INCH.

MAGNETIC & STRAIN PICK-UPS

MAGNETIC: VARIABLE RELUCTANCE & MOVING COIL

RELUCTANCE. VARIES THE RELUCTANCE OF THE MAGNETIC TYPE.



AS THE NEEDLES MOVES, THE MAGNETIC PATH FOR THE P.M. IS VARIED.

THE MOVING COIL, VARIES THE INDUCED VOLTAGE IN THE COIL BY THE P.M.

MAGNETIC TYPE! LOW Z - LOW VOLTAGE (mV)

EQUALIZATION MUST BE PROVIDED.

STRAIN TYPES! PIEZOELECTRIC EFFECT!

CRYSTAL WILL MOVE WITH A VOLTAGE APPLIED TO ITS SURFACE. ALSO IF THE CRYSTAL IS BENT A VOLTAGE WILL APEAR ON ITIS SURFACE.

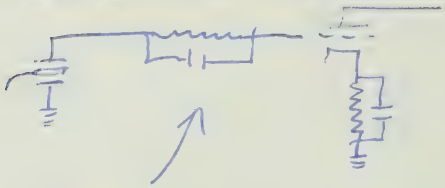
CRYSTAL — HIGH Z - HIGH VOLTAGE (½ VOLT.)

" WILL BREAKE EASY IF DROPED

HUMIDITY WILL AFFECT IT.

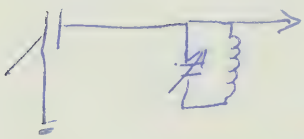
CERAMIC - MORE RUGGED LESS OUTPUT.

CRYSTAL CKT.



COMPENSATION FOR THE CAPACITANCE EFFECT ON HIGH FR. BY CRYSTAL.

F.M. PICK-UP (CONDENSER)



THE CAP. WILL CHANGE THE FR. OF THE TUNNED CKT, AS ONE SIDE OF THE CAP PLATE WILL MOVE WITH THE NEEDLE. THE VARIATIONS ARE DETECTED AND AMPLIFIED.

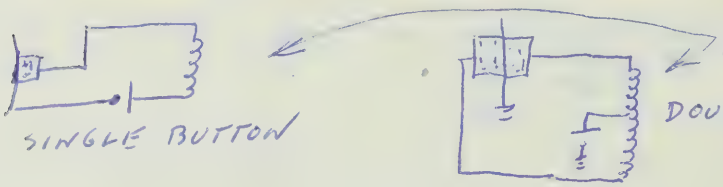
MICROPHONES:

CARBON MIKE - HIGH OUTPUT.

CHANGE OF R. IN GRANUELES WILL REPRESENT THE FR.

THE AMOUNT OF COMPRESSION WILL DETERMINE THE AMPLTUD

RANGE: LIMITED TO VOICE. PRODUCES A HISS IN THE OUTPUT DUE TO THE D.C. FLOWING IN THE CARBON.



DYNAMIC MIKE - MOVING COIL - SPEAKER DIAPHRAM. LOW Z - LOW OUT. GOOD FR. RESPONSE.

CRYSTAL MIKE - MOST POPULAR. - HIGH Z - LOW OUT.

VELOCITY MIKE - RIBON. GOOD RESPONSE - GOOD AMPLITUD

CONDENSER MIKE - FM. MIKE

OPERATES LIKE CONDENSER PICK-UP.

1 R_p for ...

2 Power in ... =

3 ... in ...

4 ... in ...

5 ...

6 Return ...

Los angeles Trade Tech. Jr. College
Instructor: R.H. Oeffinger

JS-

ELECTRONICS TECHNICIAN

JOB SHEET

Transformer Characteristics

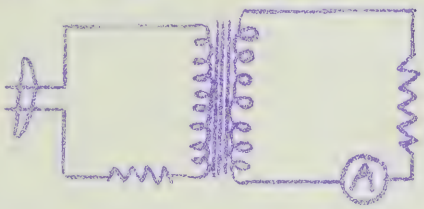
Objective: How to measure the characteristics of transformers.

Materials: Power transformer with all windings removed except primary, 5 ohm 20 watt or more resistor, 5 ohm 10 watt resistor, #30 and #20 enamel covered wire, and insulating tape.

Equipment: Voltmeter and low range AC ammeter.

Procedure: I. On top of primary wind ~~70~~ 80 turns of ~~#26~~ 30 wire. Measure voltage across primary and secondary. How many turns are in the primary? 760

II. Connect equipment as shown:



E_P = 100 V
E_S = 9.2 V.
I_S = 1.84 A.
$N_P = \frac{E_S \times N_S}{I_S} = \frac{1.84 \times 80}{760}$
I_P = .194 A.

Measure voltage across load resistor and series resistor in the primary. Record reading of ammeter in the secondary.

From data recorded to this point, solve the following:

a. Turns ratio. $\frac{4}{1}$ $\frac{760}{80}$ = $\frac{95}{1}$ $\frac{9.5}{1}$

b. Wattage in primary and secondary. $E_P I_P = 100 \times .194 = 19.4$ $E_S I_S = 9.2 \times 1.84 = 16.93$.

c. % of efficiency.

III. Wind 80 turns on top of last winding with #21 wire. Measure resistance of both secondary windings. _____

Repeat all instructions and steps as in II.

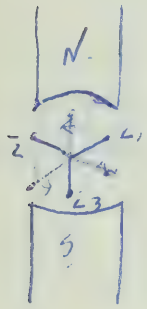
3 PHASE A.C. CIRCUITS.

GENERATION OF 3 ∅ EMF.

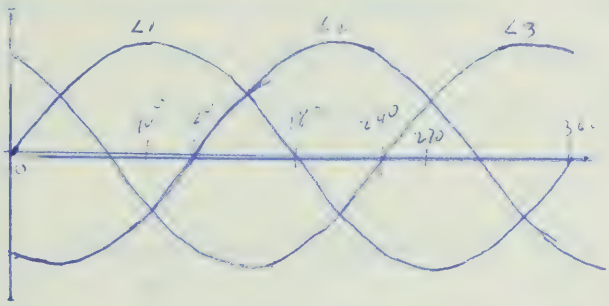
3 VOLTAGES OF EQUAL MAGNITUDE BUT DISPLACED 120°

3 WINDINGS IN AN ARMATURE 120° (MECHANICAL) APART

IN A TWO POLE, 3 ∅ GEN. ONE CYCLE FOR EACH PHASE IS PRODUCE FOR ONE MECHANICAL ROTATIO



AS EACH COIL PASES BY THE POLES IT GENE RATES A SINE WAVE



IN GENERATORS WITH MORE THAN TWO POLES, EVERY TIME A COIL PASSES THROUGH A NORTH AND SOUTH POLE IT GENENERATES A SINE WAVE OF 360°

THEREFORE IN A FOUR POLE GENERATOR WHEN ONE WINDING HAS GONE TROUGH 180° MECHANICAL DEGREES IT HAS GENERATED 360° ELECTRICAL.

SO FOR EVERY MECHANICAL DEGREE, TWO ELECTRICAL DEGREES RESULT.

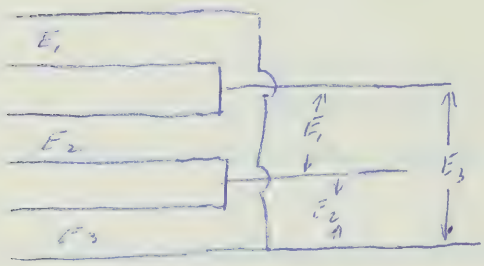
ONE CYCLE PER PHASE PER PAIR OF POLES.

THE FR. OF A GENERATOR IS THE!

$$FR. = \frac{\text{PAIRS OF POLES} \times \text{RPM.}}{60} \times \frac{1}{2} \quad \text{OR} \quad \frac{\text{POLES} \times \text{RPM}}{120}$$

$$\text{AND RPM} = \frac{60 \times \text{FR.}}{\text{P. OF P.}} = \frac{120\ \text{FR.}}{\text{POLES}}$$

IN A 3 ∅ GEN. ONE MECHANICAL DEGREE IS EQUAL TO THE NUMBER OF POLES DIVIDED BY 2 OR P/2. SINCE EACH PHASE IS TO BE 120° ELECTRICAL AND SINCE 1 MECHANICAL DEGREE EQUALS P/2 ELECTRICAL DEGREES THEN THE MECHANICAL SEPARATION OF THE WINDINGS IS $\frac{120}{P/2}$ OR $240/P$.



3 COMMON AND EQUAL VOLTAGES COMMING OUT OF THE WINDINGS OF THE GENERATOR

240 - 480 - 230 2.4 KV.

IN THRE ∅ THERE SHOULBE EQUAL VOLTAGES BETW ALL LINES

BALANCE 3 ∅ $E_1 = E_2 = E_3$

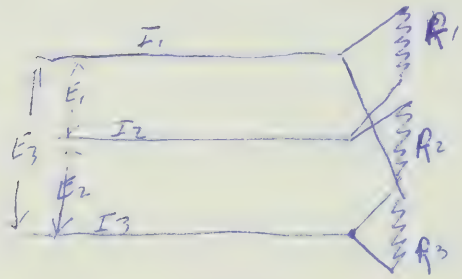
$I_1 = I_2 = I_3$

METHOD OF CONNECTING THE LOAD WINDINGS.

DELTA OR STAR OR WYE

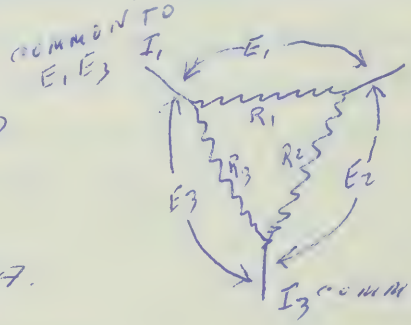
Δ OR Y.

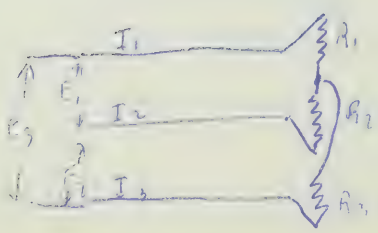
IN A DELTA SYSTEM ALL WINDINGS ARE CONNECTED IN SERIES FORMING A CLOSED LOOP.



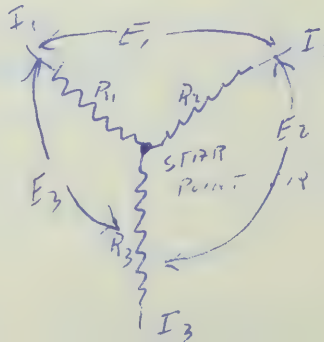
SIMPLIFIED CKT

DELTA.





SIMPLIFIED



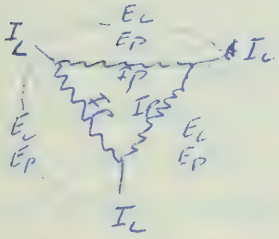
IS REFERENCE PO

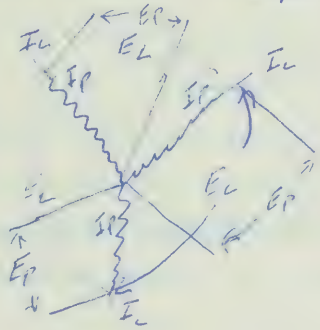
THE STAR POINT IS THE COMMON POINT TO ALL WINDING THEREFORE IT IS THE REFERENCE POINT

IN THREE PHASE CKTS THERE IS FOUR DIFFERENT CURRENTS AND VOLTAGES, THEY ARE 3 DIFFERENT PHASE VOLTAGES AND THE LINE VOLTAGE. AND THREE DIFFERENT PHASE CURRENTS AND A LINE CURRENT.

SINCE ALL 3 Ø CKT SHOULD BE BALANCED WE WILL CONSIDER ONLY BALANCED CKTS, WHERE ALL 3 PHASE CURRENTS AND VOLTAGES ARE EQUAL.

THEREFORE WE HAVE LINE VOLTAGE = "E_L" AND PHASE VOLTAGE = "E_P". ALSO LINE CURRENT = "I_L" AND PHASE CURRENT = "I_P"

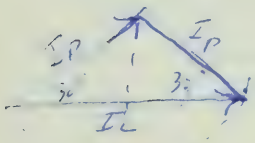




BALANCED CKTS.

IN A DELTA THE E_L VOLTAGE BETWEEN ANY TWO LINES IS EQUAL TO THE VOLTAGE IN A SINGLE PHASE. THEY ARE IN PHASE

THE CURRENT I IN THE LINE IS NOT THE SAME THAT ON ANY PHASE BECOUSE IT FLOWS ON DIFFERENT PHASES THEREFORE I_L IS 30° OR 150° OUT PHASE WITH I_P SINCE I_L IS THE VECTOR SUM OF THE TWO I_P



SINCE THE VECTOR SUM OF TWO EQUAL I_P AND FORM A PARALLELOGRAM WITH EQUAL SIDES, THE LINE CURRENT VECTOR IS FOUND BY MULTIPLYING THE PHASE CURRENT "I_P" BY 2 TIMES THE COS OF 30°. SINCE THE COS OF 30° IS .866, AND TWICE THE COS OF 30° IS

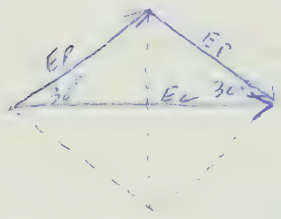
1.732 WHICH IS THE $\sqrt{3}$ THEN THE LINE CURRENT IS EQUAL TO THE PHASE CURRENT TIMES THE $\sqrt{3}$

THEREFORE IN A <u>DELTA</u> CONNECTION

$E_L = E_P$ $\quad I_L = I_P 2\cos 30^\circ$ OR $I_L = I_P\sqrt{3}$

$I_P = I_L/\sqrt{3}$

STAR OR WYE CONECTIONS.
THE CURRENT IN THE ~~PHASE~~ LINE IS IN PHASE W. TH THE CURRENT IN THE WINDINGS. $I_L = I_P$
THE VOLTAGE BETWEEN TWO LINES OR E_L IS NOT THE SAME THAT THE VOLTAGE IN ANY WINDINGS, BECAUSE THERE IS TWO WINDINGS CONECTED IN SERIES BETWEEN THE LINES, BUT IS EQUAL TO THE VECTOR SUM OF THE E_P IN BOTH OF THIS WINDINGS. THE SUM OF THIS TWO VECTORS ALSO FORM A PARALLELOGRAM WITH EQUAL SIDES.



E_L THEN LIKE THE CURRENT IN TH DELTA EQUALS E_P MULTIPLY BY 2 TIMES THE COS OF 30° OR $\sqrt{3}$

THEREFORE IN A <u>STAR OR WYE</u>

$I_P = I_L$ $\quad E_L = E_P 2\cos 30^\circ$ OR $E_P\sqrt{3}$

$E_P = \dfrac{E_L}{\sqrt{3}}$

CHECK A.C. T.M. FOR 3 ϕ TRANSFORMER CONNECTIONS.

POWER IN 3 PHASE!

MORE POWER IN THE DELTA CKT THAN THE STAR (~~73%~~ more) 3 times more

$$P = I^2 R = EI = \frac{E^2}{R}$$

POWER IN A STAR CKT.
TOTAL POWER = P_T

$$P_T = P_P\, 3 \qquad I_L = I_P$$

$$P_P = E_P I_P \text{ SINCE } E_P = \frac{E_L}{\sqrt{3}} \text{ THEN } P_P = \frac{E_L}{\sqrt{}} I_L$$

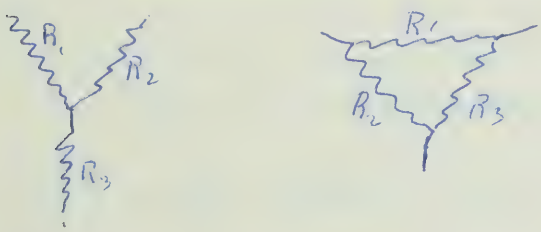
$$P_T = 3\,\frac{E_L I_L}{\sqrt{3}}$$

POWER IN A DELTA CKT:

$$E_P = E_L \qquad I_P = \frac{I_L}{\sqrt{3}}$$

$$P_P = E_L \frac{I_L}{\sqrt{3}} \qquad \text{~~$P_T = 3 E_L I_L$~~} \qquad P_T = E_L \frac{I_L}{\sqrt{3}}\, 3$$

EQUIVALENT CKT CONSIDERING THE WINDINGS AS RESISTORS:



BALANCED CKT
ALL RESISTANCES EQUAL

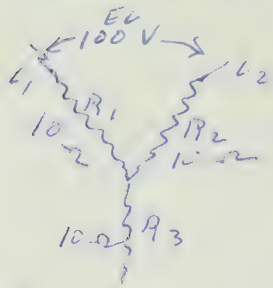
COMPARING STAR & DELTA FOR SAME POWER.
BUT SINCE DELTA HANDLES MORE POWE THE RESISTANCES IN EACH PHASE ARE DIFFERENT.
THE EQUIVALENT RESISTANCE BETWEEN TWO LINES MUST BE THE SAME ~~IS~~ IN BOTH CASES.

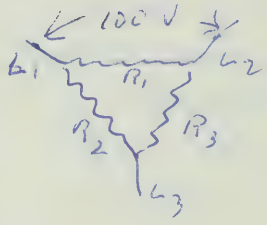
RATIOS: $R_{P\Delta} = 3\, R_{P\star}$

$$\text{TURNS}_\Delta = \sqrt{3}\ \text{TURNS}_\star$$

$$\Delta CM = \frac{CM_\star}{\sqrt{3}}$$

CHANGING FROM STAR TO DELTA WITH EQUAL POWER





$R_{P\Delta} = 30$

IN THE STAR THE TOTAL R. BETWEEN L_1 & L_2 IS 20 Ω COMPOSED OF R_1 & R_2 IN SERIES IN THE DELTA THEN THE TOTAL R. BETWEEN L_1 & L_2 MUST BE 20 Ω COMPOSSED OF R_1 WITH R_2 & R_3 IN PARALELL.

SINCE THE P IN STAR MUST EQUAL THE POWER IN THE DELTA.

$P_{P\curlywedge} = I_P^2 R_{P\curlywedge}$ $\quad P_{P\Delta} = I_P^2 R_{P\Delta}$

$P_{P\curlywedge} = I_L^2 R_{P\curlywedge}$ $\quad P_{P\Delta} = \left(\frac{I_L}{\sqrt{3}}\right)^2 R_{P\Delta}$

SINCE $P_{P\curlywedge} = P_{P\Delta}$ THEN $I_L^2 R_{\curlywedge} = \left(\frac{I_L}{\sqrt{3}}\right)^2 R_\Delta$

DIVIDING BY I_L^2 $= R_{\curlywedge} = \frac{R_\Delta}{\sqrt{3}^2} = \frac{R_\Delta}{3}$ SQUARIN $\sqrt{3}^2 = 3$

IF $R_{P\curlywedge} = \frac{1}{3} R_{P\Delta}$ THEN $\underline{R_\Delta = 3 R_{\curlywedge}}$

THE IN NUMBERS. $R_{P\Delta} = 10 \times 3 = 30$

ALSO $P_{P\curlywedge} = \frac{E_P^2}{R_{\curlywedge}}$ $\quad E_P = \frac{E_L}{\sqrt{3}}$ THEN $P_{P\curlywedge} = \frac{\left(\frac{E_L}{\sqrt{3}}\right)^2}{R_{\curlywedge}} =$

$= \frac{\left(\frac{100}{\sqrt{3}}\right)^2}{10}$ OR $\frac{10000}{3} = 333.3$ W.

$P_{P\Delta} = \frac{E_P^2}{R}$ OR $\frac{10000}{30} = 333.3$

ALSO $P_\Delta = \frac{10000}{R_\Delta} = 333.3$ $\quad R_\Delta = \frac{10000}{333.3} = \underline{30\ \Omega}$ $R_{P\Delta}$

EQUIVALENT PARALLEL IN DELTA $\frac{1}{\frac{1}{30} + \frac{1}{30+30}}$

$\frac{1}{\frac{3}{60}}$ OR 20 SAME AS IN STAR

3 ∅ POWER

$$P_T = I^2 R_E \sqrt{3}$$

WHERE R_E WILL BE ACTUAL RESISTANCE FROM LINE TO LINE. OR ACTAL OPPOSITION. SINCE THERE IS A CERTAIN CURRENT DRAIN TROUGH THE OTHER LINE THE ACTUAL R. FROM LINE TO LINE THEN

$$R_E = \frac{P_T}{I^2 \sqrt{3}}$$

OR $R_{\text{A}\phi} = \frac{R_E}{\sqrt{3}}$ IN Δ $R_\Delta = R_E \sqrt{3}$.

$R_{E\text{A}} = R_{\text{A}} \sqrt{3}$ $R_{E\Delta} = \frac{R_\Delta}{\sqrt{3}}$

FREQUENCY MODULATION.....

THE FR. OF THE CARRIER IS VARIED AT AN AUDIO RATE
THE AMPLITUD OR STREGHTH IS CONSTANT.

THE AMOUNT OF DEVIATION DEPENDS ON THE AMPLITUD OF THE MODULATING AUDIO SIGNAL.

THE POSITIVE PEAK INCREASES THE CARR. FR.
THE NEGATIVE PEAK DECREASES THE CARRIER FR.

THE RATE OF FR. CHANGE, DEPENDS UPON THE FR. OF THE MODULATING SIGNAL.

THE MAXIMUM FR. DEVIATION ALLOWED IS 75 KC. ABOVE OR BELOW THE REST FR. FOR A TOTAL BANDWITHD OF 150 KC. (CARRIER 1/2 SWING)

FM IS LIMITTED TO HIGH FR. BECAUSE OF THE NEED FOR WIDE BANDWITHD.

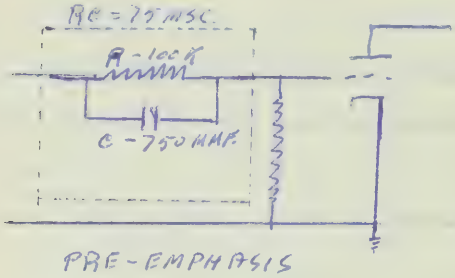
SIDE-BANDS IN FM.
IN FM AS THE SIDE BANDS INCREASE, THE CARRIER POWER DECREASES. THIS IS BECAUSE MODULATION CAUSES POWER FROM THE CARRIER TO BE SHIFTED TO THE SIDE-BANDS SO AS TO MAINTAIN THE TOTAL POWER CONSTANT.
THE SIDE BANDS AMPLITUD AND FR. ARE DETERMINED BY THE AUDIO FR. AND THE FR. DEVIATION.

THE SIDE BANDS IN FM ARE SO ORIENTED, WITH RESPECT TO THE CARRIER COMPONENT, THAT THE FR. OF THE RESULTANT COMPONENT WAVE WILL SHIFT A MAXIMUM AMOUNT, THE SIDE BANDS ARE SHIFTED 90° IN PHASE.

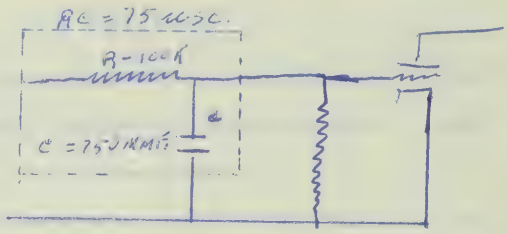
FM HAS MORE FREEDOM FROM INTERFERENCE & NOISE SINCE THIS IS USUALLY AMPLITUD MODULATED.

IN TRANSMITING FM. THE HIGH FR. ARE PRE-EMPHASIZED. THIS IS TO PREVENT NOISE IN THE RECEIVER OR TO IMPROVE THE SIGNAL TO NOISE RATIO.

NOISE AND RANDOM PULSES ARE MORE FREQUENT IN THE HIGH FR. BRACKET OF AUDIO. THIS NOISE COULD BE CUT-DOWN BY DE-EMPHASIS, BY THE FIDELITY OF THE HIGH FR. WILL ALSO BE CUT-DOWN. THEREFORE IN THE TRANSMITTER THE HIGH FR. ARE EMPHASIZE, AND IN THE RECEIVER THEY ARE DE-EMPASIZED.



PRE-EMPHASIS



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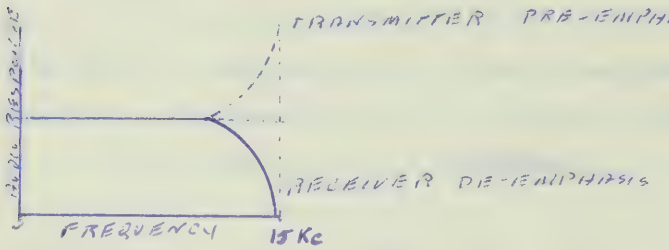
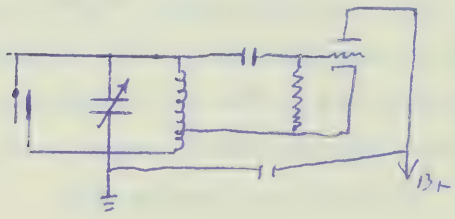


METHODS OF FM.

DIRECT FR. MODULATION (MOST SYMPLE)



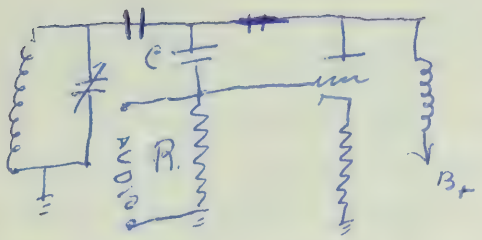
USING A CONDENSER MIKE. WHEN SOUND STRIKES THE MIKE IT WILL VARY THE FR. OF THE OSCILLATOR.

THIS TYPE OF CKT IS NOT TOO STABLE.

REACTANCE TUBE MODULATOR:

THE REACTANCE TUBE MODULATOR, MODULATES THE FR. AT THE SOURCE OR OSCILLATOR.

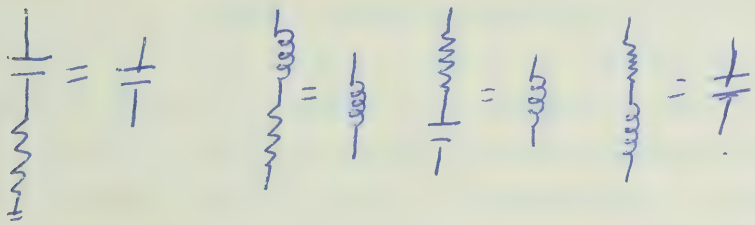
THE TUBE IS WIRED A.C IN TO A PARTICULAR OSCILLATOR SO THAT IT'S IMPEDANCE - FROM PLATE TO GROUND IS SIMILAR TO A REACTANCE. THE CHARACTERISTIC OF A REACTANCE, CAUSES THE CURRENT FLOWING THROUGH IT TO BE 90° OUT OF PHASE WITH THE VOLTAGE ACROSS IT. BY REPRODUCING THIS RELATIONSHIP A TUBE CAN SIMULATE A REACTANCE.



REACTANCE TUBE.

CAP "C" AND RES. "R" ACT CAPACITIVE WITH THE VOLTAGE IMPRESSED ACROSS IT, BEING OUT OF PHASE WITH THE CURRENT. THIS PHASE ANGEL IS PICKED UP IN THE TANK OF THE PLATE CKT. IF IT IS PART OF AN OSCILLATOR, THE TUBE WILL LOOK AS A REACTANCE.

BY USING ~~=~~ DIFFERENT COMBINATIONS OF COMPONENTS IN "C" & "R" THE TUBE CAN BE MADE TO LOOK LIKE A DIFFERENT REACTANCE.



THIS DIFFERENT COMBINATIONS MAKE THE I_p REACT DIFFERENTLY, AND CHANGE THE G_m.

IN CAPACITIVE EFFECT:

I_p ↑ G_m ↑ CAP ↑ FR. ↓

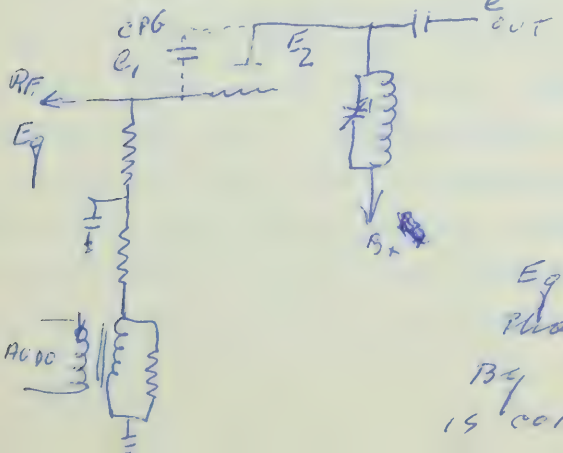
I_p ↓ G_m ↓ CAP ↓ FR ↑

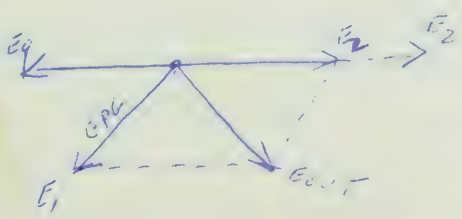
IN INDUCTIVE EFFECT:

I_p ↑ G_m ↑ IND ↓ ~~=~~ FR. ↑

I_p ↓ G_m ↓ IND ↑ FR ↓

PHASE MODULATION: THE PHASE ANGLE OF THE R.F. WAVE IS CHANGED TO PRODUCE FM.

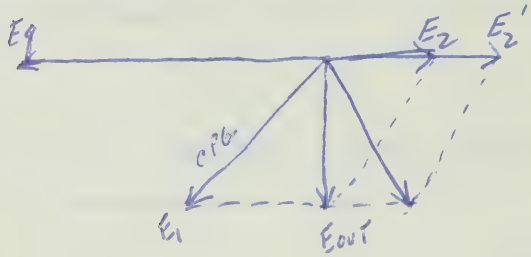




E_g and E_2 are 180 degrees out of phase. THE FEEDBACK VOLTAGE E_1 BY THE INTERELECTRODE CAPACITANCE IS CONSTANT AND LEADING E_g

E_{out} IS THE RESULTANT OF ADDING E_1 AND E_2 OR THE GRID TO PLATE CAPACITANCE VOLTAGE ADDED VECTORIALLY TO THE PLATE VOLTAGE.

E_p IS CONSTANT. E_2 WILL VARY AS THE I_p VARIES.



IF THE PLAT VOLTAGE E_2 INCREASES DUE TO I_p DECREASE, THE PHASE ANGLE WILL ADVANCE. AND VICE-VERSA.

PHASE CHANGE REPRESENTS THE AMPLITUD OF THE SIGNAL - THEREFORE THE AMOUNT OF DEVIATION.

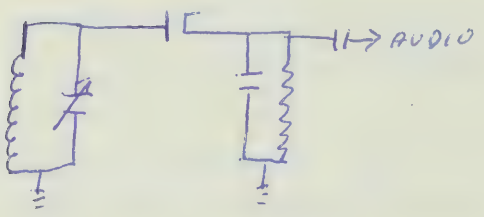
BY VARYING THE G_m OF THE TUBE, THE VOLTAGE WILL VARY AT THE R_L, THEREFOIRE THE PLATE VOLTAGE WILL VARY BETWEEN 180 & 90° due TO THE INTERELECTRODE CAPACITANCE.

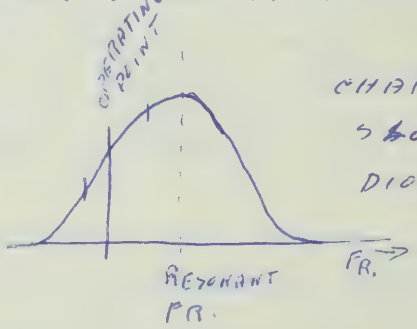
PHASE MODULATION OVEREMPHASIZES LOW FR.

DETECTION OF FM.

SLOPE DETECTOR.

A DIODE DETERTOR WHICH MUST DETECT CHANGES OF FR.

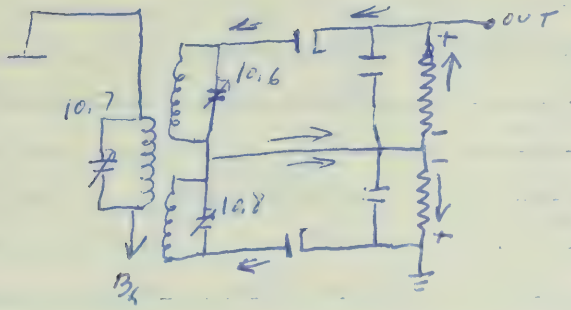




CHARACTERISTIC SLOPE OF THE DIODE TUNED CKT

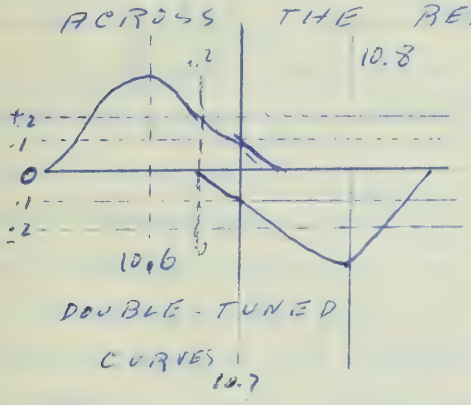
THE TUNNED CKT IS SLIGHTLY DETUNNED TO A LOWER FR. SO IT OPERATES IN THE SLOPE OF THE CURVE. THE FR. VARIATIONS MUST NOT REACH THE PEAK OR DISTORTION WILL BE ENCOUNTERED. THE VARIATIONS OF VOLTAGE AS THE FR. VARIES WILL BE FOUND ACROSS THE RESISTOR. THE AMPLITUD OF THE AUDIO WILL DEPEND UPON HOW FAR THE FR. DEVIATES.

DOUBLE-TUNNED DETECTOR



THE PRIMARY CKT IS TUNED BROADLY TO THE I.F OR REST FR. THE SECONDARY CKT ARE TUNED ONE HIGHER AND ONE LOWER (FR.).

IF THE REST FR. (NO MOD) COMES ALONG, THE VOLTAGE INDUCED IN BOTH SECON. WILL BE EQUAL SINCE BOTH ARE TUNED TO A DIFFERENT FR. THAN THE REST. FR. BOTH DIODES CONDUCT, AND THE VOLTAGE ACROSS BOT RESISTORS ARE EQUAL AND OPOSITE, THEREFORE THE OUTPUT IS ZERO. THE CAP. ACROSS THE RESISTORS ARE BY-PASS. CAP.

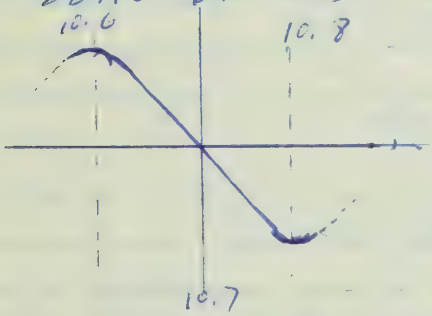


DOUBLE-TUNED CURVES

SINCE, BOTH DETECTORS PRODUCE +.1 VOLT OR -.1 VOLT RESULT IS ZERO.

IF THE FR. SHIFTS DOWNWARD TO WERE LOWER DIODE CONDUCTS TO A POSITIVE .2 VOLTS WE SEE THAT THE OTHER DIODE HAS ZERO VOLTS

THE TOTAL OUTPUT TIHEN IS +.2 VOLTS. IF THE FR. IS DEVIATING SYMETRICALLY THEN ON THE NEXT HALF CYCLE OF AUDIO GO UP THE SAME AMOUNT, AND THE UPPER DIODE WILL PRODUCE A -.2 VOLTS FOR ZERO OF THE LOWER FR. DIODE.

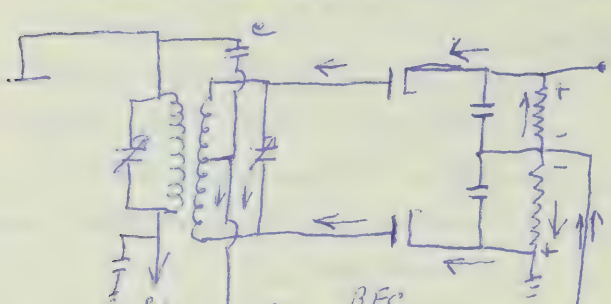


RESULT S. CURVE FROM ADDING THE VARYING VOLTAGES ACROSS THE LOAD RESISTORS.

THIS DETECTOR HAS THE DISADVANTAGE THAT IT HAS THREE DIFFERENT CKTS TO TUNE, AND AT THREE DIFFERENT FR. WHICH SOMETIMES IS CRITICAL.

THE NEXT DETECTOR (FOSTER-SEELEY DISCRIMINA IS AN INPROVEMENT OVER THIS ONE

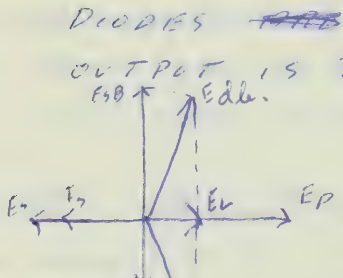
DISCRIMINATOR (FOSTER-SEELEY)



PRIMARY AND SECONDARY CKTS ARE TUNED TO THE I.F. FR.

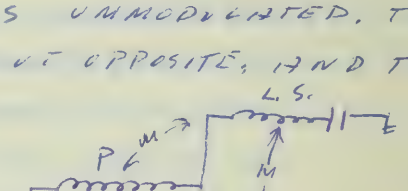
THE R.F. IS INDUCTIBLY COUPLED AND CAPACITIVE COUPLED THROUGH C. TO THE CENTER TAPED SEC. THIS PRODUCES A VOLTAGE ACROSS THE R.F.C.

WHEN THE INCOMING SIGNAL IS UNMODULATED, THE DIODES ~~PRODUCE~~ HAVE EQUAL VOLTAGE BUT OPPOSITE, AND THE OUTPUT IS ZERO

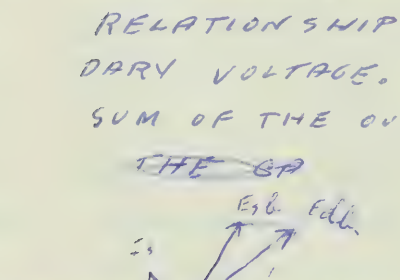


REST FR.

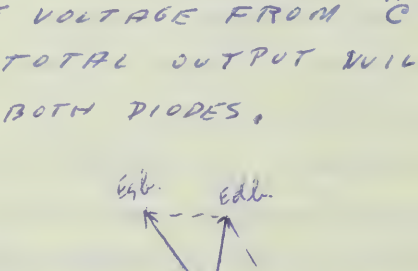
Ep THE PRIMARY VOLTAGE IS THE REFERENCE VOLTAGE



IF THE FR. IS HIGHER OR LOWER THAN THE REST FR. THE VOLTAGES ACROSS THE SECONDARY ARE ADDED OR SUBTRACTED FROM THE CAP. "C" PATH. SO ONE DIODE WILL HAVE MORE VOLTAGE THAN THE OTHER AT ONE INSTANT AND VICEVERSA. THIS IS DUE BECAUSE OF THE PHASE RELATIONSHIP OF THE VOLTAGE FROM "C" AND THE SECONDARY VOLTAGE. THE TOTAL OUTPUT WILL BE THE ALGEBRAIC SUM OF THE OUTPUT OF BOTH DIODES.



ABOVE FR.



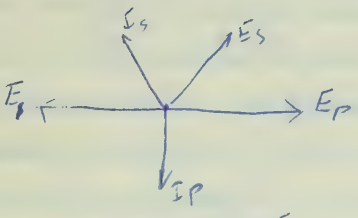
BELOW REST FR.

THE CAPACITORS ACROSS THE LOAD R.F. BY-PASS

C - COUPLING CAP.

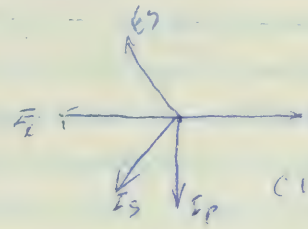
R.F.C - TO PROVIDE D.C. RETURN TO DIODES AND MAINTAIN CENTER TAP - ABOVE R.F. GROUND.

IF FR GOES U.P (SECONDARY BEING SERIES TUNED) THE CKT BECOMES INDUCTIVE.



INDUCTIVE

... IF FR GOES DOWN CKTS ACT CAPACITIVE. ...



CAPACITIVE

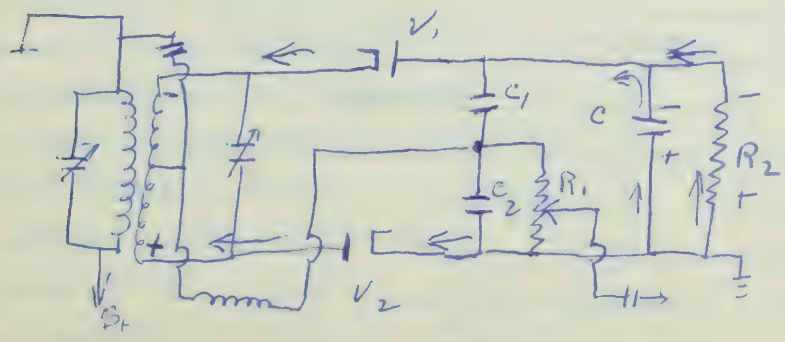
THE MAIN ADVANTAGE OF THE FOSTER-SEELEY IS THAT IT ONLY HAS ONE SECONDARY TO TUNE AND TO SAME FR.

RATIO DETECTOR:

THE FOSTEER SEELEY RESPONDS TO AMPLITUD MODULATION AS WELL AS FM, WHICH WILL PRODUCE DISTORTION. EXAMPLE: IF THE MODULATED WAVE WILL PRODUCE A VOLTAGE OF 4 VOLTS ACROSS ONE RESISTOR AND 2 VOLTS ACROSS THE OTHER, FOR A NET OUTPUT OF 2 VOLTS. IF THE AMPLITUD WILL NOW CHANGE TO DOUBLE, THE VOLTAGE DROP BECOMES 8 AND 4 VOLTS OR A NET OUTPUT OF 4 VOLTS. THIS CHANGE WILL PRODUCE DISTORTION, SINCE IS A CHANGE PRODUCED BY AM. BUT THE RATIO DOES NOT CHANGE BETWEEN THE TWO RESISTORS, THEREFORE THE DISCRIMINATOR, DETECTS AM AND FM.

AN FM DETECTOR WHICH RESPONDS ONLY TO THE RATIO BETWEEN THE VOLTAGES BUT NOT RESPONDS TO THE DIFFERENCE OF THE VOLTAGES IS THE RATIO DETECTOR

THE BASIC RATIO DETECTOR



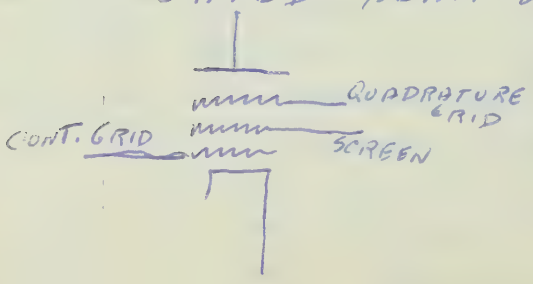
THE TUNED CKT AND COUPLING OF THE RATIO DETECTOR IS THE SAME AS THE DISCRIMINATOR.

BOTH TUBES WITH R_2 ARE IN SERIES WHICH ARE FED BY THE SECONDARY. BOTH DIODES CONDUCT ON THE SAME I.F. HALF CYCLE. WHEN THE LOWER HALF OF THE XFORMER IS POSITIVE, CONDUCTION IN A VOLTAGE DROP HAVING THE POLARITY SHOWN APPEARS ACROSS R_2. C (ELECTROLYTIC) CHARGES TO THE SAME VALUE. "C" TENDS TO HOLD CONSTANT THE VOLTAGE WHICH APPEARS ACROSS THE RESISTOR. AS A RESULT OF CONDUCTION THROUGH THE SERIES CKT. A NEGATIVE POTENTIAL APPEARS AT THE PLATE OF V1 BECAUSE R_2. SINCE "C" IS SO LARGE THIS VOLTAGE IS MAINTAINED AT A CONSTANT VALUE EVEN AT LOW FR.

C_1 & C_2 ARE ACROSS THEIR TUBES THROUGH A PORTION OF THE SECONDARY WINDING. SO WHEN THE VOLTAGE ACROSS V_1 INCREASES OR DECREASES THE D.C POTENTIAL ACROSS C_1 DOES THE SAME THING AND V_2 & C_2. THEREFORE THE VOLTAGE ACROSS C_2 IS ALWAYS PROPORTIONAL TO THE VOLTAGE ACROSS C_1. SINCE THE D.C. VOLTAGES ACROSS THE DIODES DIFFER ACCORDING TO FR. THE VOLTAGE ACROSS THE CAPACITORS DIFFER IN THE SAME PROPORTION. THE AUDIO OUTPUT WHICH IS TAKEN FROM ACROSS C_2 IS A FUNCTION OF THE SIGNAL.

SINCE C_1 & C_2 ARE IN SERIES ACROSS "C" REGARDLESS OF THE RATIO OF THEIR VOLTAGES, THE SUM OF THE TWO VOLTAGES MUST REMAIN THE SAME AS IT MUST EQUAL THE CHARGE IN "C" WITH THE SUM OF THE TWO VOLTAGES BEING A FIXED VALUE, THE OBJECTION OF THE DISCRIMINATOR IS NO MORE. NO AM IS DETECTED.

GATED-BEAM DETECTOR - 6BN6



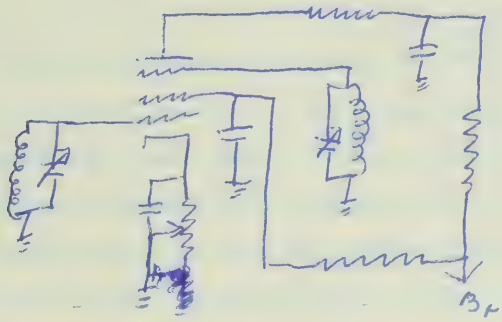
THE ~~CATHODE~~ CATHODE OF THIS TUBE OPERATES AT CONSTANT CURRENT. THE TUBE HAS TWO GATES, THE CONTROL GRID & THE QUADRATURE GRID, IF ONE IS OPEN AND THE OTHER CLOSED THE T

TRONS EMITTED BY THE CATHODE ARE RETURNED BY THE ACCELERATORS BACK TO THE CATHODE. WHEN BOTH GATES ARE OPEN, MAXIMUM I_P IS ACHIEVED IMMEDIATLY. THERE FORE THE OPERATES EITHER AT CUT-OFF OR SATURATION - "NO IN BETWEEN"

BY INJECTING A SINE WAVE TO A GATED BEAM TUBE CKT. A SQUARE-WAVE CAN BE OBTAINED, SINCE IT OPERATES AT CUT-OFF AND SATURATION.

THE TUBE WILL BE BIASED AT THE SINE WAVE ZERO (REFERENCE LEVEL). SATURATION CLIPS.

AS A DETECTOR:



AS THE BIAS POINT IS LOWERED PAST CUT-OFF PLATE CURRENT INCREASES TO SATURATION.

WHEN MODULATED ELECTRON STREAM PASSES THE QUADRATURE GRID THE TANK CKT WILL OSCILLATE AT THIS FR. WHICH IS THE REST FR. THE ELECTRON STREAM FORMS A CAPACITIVE EFFECT IN THE QUAD. GRID, THE CURRENT IN THE GRID LEADS THE LIMITER CURRENT BY 90°.

AN FM SIGNAL APPLIED TO THE CONTROL GRID PRODUCES A SET OF VOLTAGE PULSES AT THE QUAD. GRID 90° OUT OF PHASE. PRODUCING I_P PULSES WHICH VARY IN TIME WITH THE MODULATION SINCE THE QUADRATURE GRID AND CONTROL GRID MUST OPEN AT THE SAME TIME.

THE CHANGING CAP. OF THE TUBE WILL VARY THE FR. OF THE TUNED CKT BY CHANGING THE PHASE BY 90°. (MORE OR LESS).

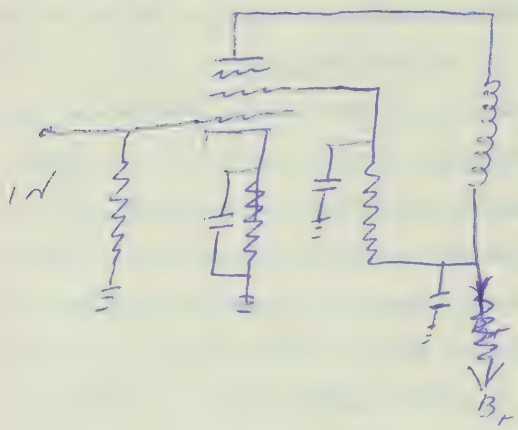
FM. LIMITERS:

USED TO CLIP BOTH SIDES OF THE WAVE AMPLIFIED TO ELIMINATE DISTORTION OR NOISE RIDING ON THE PEAKS.

PLATE CKT LIMITING. (SATURATION)

THE OUTPUT NEGATIVE PEAKS OF VOLTAGE ARE

CLIPPED BY SATURATION OF EP.



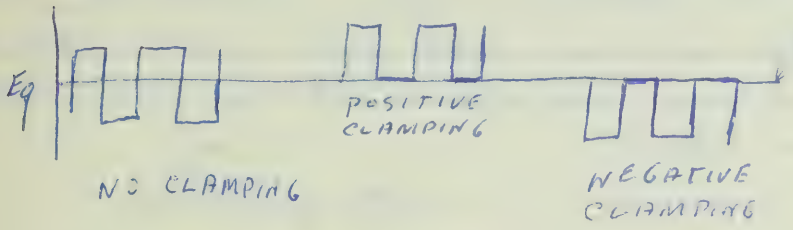
THE PLATE AND SCREED DROPPING RESISTORS DROP THE B+ LOW SO THAT SATURATION MAY BE REACHED SOONER WITH LOW PLATE VOLTAGE. (30 VOLTS OR LESS) ALSO BY SELECTING THE RIGHT VALUE OF BIAS, CUT-OFF CAN ALSO BE REACHED, AND LIMITING OBTAIN ON THE OUTPUT POSITIVE PEAKS OF VOLTAGE.

~~GRID LIMITING~~

CLAMPING CIRCUITS: D.C. RESTORATION.

TO RECOVER THE D.C POTENTIAL REFERENCE LEVEL

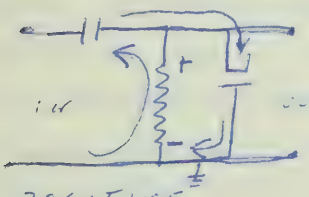
DIODE OR GRID CLAMPING, CLAMPS EITHER EXTREME OF THE WAVE AND ALLOWS IT TO EXTEND ONLY IN ONE DIRECTION FROM THE REFERENCE LINE. OR POSITIVE AND NEGATIVE CLAMPING.



THE OUTPUT OF AN RC COUPLING CKT IS AN ALTERNATING VOLTAGE ABOUT THE AVERAGE LEVEL OF THE APPLIED VOLTAGE.

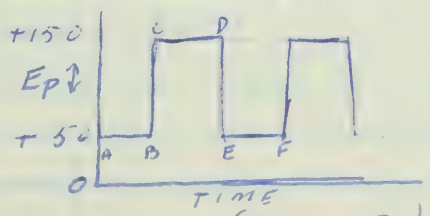
IF THE CAP. CAN BE MADE TO CHARGE TO THE MINIMUM APPLIED VOLTAGE, ANY SWING HAS TO BE IN THE POSITIVE DIRECTION, AND THE OUTPUT VARIES BETWEEN ZERO AND SOME POSITIVE VALUE. AND THE REVERSE FOR A NEGATIVE VALUE. IN ONE CASE THE BOTTOM OF THE WAVE IS CLAMPED TO ZERO, AND IN THE OTHER THE TOP IS CLAMPED TO ZERO.

DIODE CLAMPING: THIS SIMPLEST CLAMPING CKT. DIODE WITH AN R.C. NETWORK. IN THIS CASE THE CAP. VOLTAGE IS KEPT AT MINIMUM APPLIED



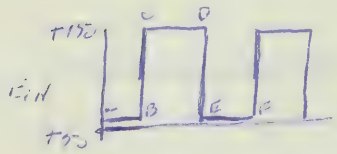
POSITIVE CLAMPING.

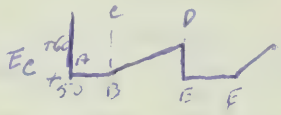
PLATE VOLTAGE VARIATION APPLIED TO THE DIODE CLAMPER:

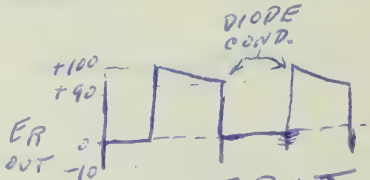


THE CAP. CHARGES THROUGH THE RESISTOR. AFTER A PERIOD OF TIME THE CAP CHARGES TO +50 VOLTS (A TO B) SINCE THIS IS THE APPLIED VOLTAGE, NO CURRENT FLOWS THROUGH THE RESISTOR. AT POINT B THE APPLIED VOLTAGE VOLTAGE GOES TO +150 V. THE DIFFERENCE OF

150 + 50 MUST APPEAR ACROSS THE RESISTOR. WHICH IS 100 V. BEING THE OUTPUT VOLTAGE WITH THE BOTTOM BEING NEGATIVE, THE DIODE DOES NOT CONDUCT. DURING TIME C TO D THE CAP CHARGES SOME MORE BUT NEVE TO THE APPLIED VOLTAGE SINCE THE T.C IS VERY LONG. THE OUTPUT ACROSS THE R. WILL DROP BY THE AMOUNT CHARGED IN THE CAP. AT TIME D. THE APPLIED DROPS TO 50, MAKING THE TOP OR CATHODE SIDE NEGATIVE, THE TUBE WILL CONDUCT DISCHARGING THE CAP. VERY RAPIDLY AND THE VOLTAGE ACROSS THE RESISTOR IS ZERO, RETURNING THE OUTPUT TO ZERO



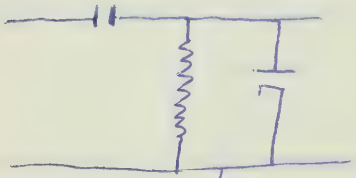




OUTPUT CLAMPED AT ZERO.

THE SMALL NEGATIVE PEAK IN THE OUTPUT IS DUE TO THE SMALL CHARGED ALLOWED THE CAP. FROM C TO D AND THEN ADDING TO THE APPLIED WHEN IT REVERSES.

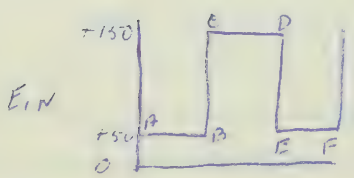
NEGATIVE DIODE CLAMPING

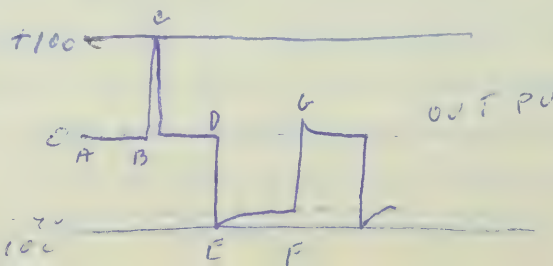


NEGATIVE CLAMPING

IF THE SAME INPUT SIGNAL IS APPLIED THE OUTPUT WILL BE REVERSED SINCE THE DIODE IS REVERSED.

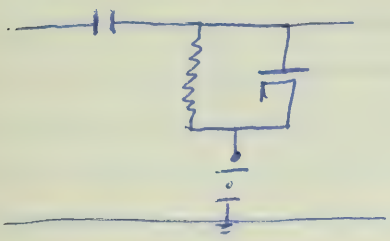
AT POINT A THE PLATE IS POSITIVE AND THE DIODE CONDUCTS CHARGING THE CAP TO +50 V. THE OUTPUT IS ZERO. AT POINT B THE APPLIED GOES TO 150 PUTTING 100 THROUG THE R. THIS MAKES THE PLATE MORE POSIT. CHARGING THE CAP TO 100 V BRINGING THE OUTPUT BACK TO ZERO. AT POINT D THE VOLTAGE DROPS 100 V. THIS -100 V. APEAR IN R. SENDING THE OUTPUT TO -100. DURING E TO F THE CAP. DISCHARGES SLIGHTLY.



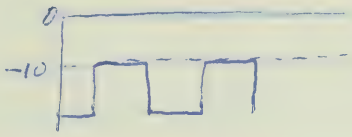


OUTPUT CLAMPED AT ZERO

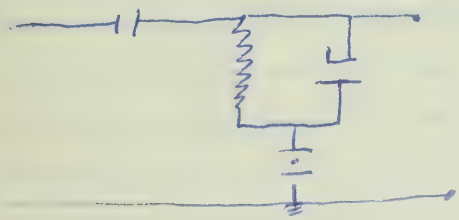
CLAMPING ABOVE AND BELOW GROUND.



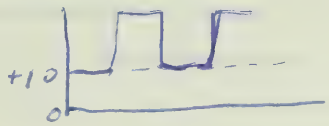
NEGATIVE CLAMPING AT −10 V BELOW GROUND.



WITH A POTENTIAL IN THE CATHODE. THAT POTENTIAL BECOMES THE REFERENCE LEVEL ~~out~~ TO WHERE THE TUBE DISCHARGES THE CAP.

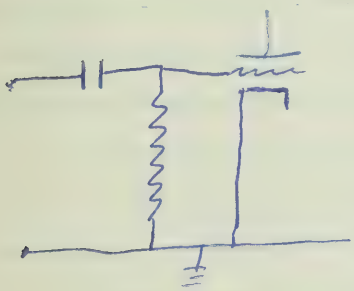


POSITIVE CLAMPING AT 10 V POSITIVE



THE TUBE WILL DISCHARGE THE CAP. TO 10 VOLTS, BECAUSE IF THE SIGNAL GOES BELOW +10 VOLTS THE TUBE WILL NOT CONDUCT.

GRID CLAMPING. ~~C~~CLAMPING MAY BE DONE BY ANY ELEMENT OF THE TUBE. ANY ELEMENT MADE POSITIVE WITH RESPECT TO CATHODE ATRACTS ELECTRONS FROM IT A VICE VERSA IF MADE NEGATIVE.



THUS THE GRID OF A TUBE CONNECTED AS SHOWN WILL ACT AS THE PLATE OF A DIODE AND PRODUCE CLAMPING.

R. C OSCILLATORS OR SAWTOOTH GENERATORS:

MICRO-MICRO

KILO

RULE →

$$\frac{72{,}000}{.0009} = \frac{72 \times 10^3}{9 \times 10^{-4}} = \frac{72}{9} \times 10^{7} = 8 \times 10^{7}$$

$$R_T = \frac{1}{\quad} = \frac{1}{\quad} = \frac{\quad}{\quad}$$

RECIPROCALS. [illegible]

$$\frac{1}{\quad} =$$

EXAMPLE: [illegible]

$$= \frac{1}{4 \times 10^{4} \times 2.5 \times 10^{-2} \times 1.25 \times 10^{-4}} = [illegible]$$

AND CHANGE SIGN.

$$\frac{10^{4}}{4 \times 2.5 \times 1.25} = \frac{10^{4}}{12.5} = \frac{10^{4} \times 10^{1}}{12.5} = \frac{10^{5}}{[illegible]} = [illegible]$$

POWER OF A POWER.

RULE → IN FINDING THE POWER OF A POWER THE EXPONENTS ARE MULTIPLIED.

$$(100)^3 = 100 \times 100 \times 100 = 1{,}000{,}000 = 10^6$$
$$(100)^3 = (10^2)^3 = 10^{2 \times 3} = 10^6$$

$$(1.9 \times 10^{-4})^3 = (1.9)^3 \times 10^{3(-4)} = 6.859 \times 10^{-12}$$
$$(.0000075)^2 = (7.5 \times 10^{-6})^2 = (7.5)^2 \times 10^{-6 \times 2} = 56.25 \times 10^{-12}$$

RULE → POWER OF A PRODUCT IS THE [illegible] OF THE PRODUCT OF THE POWERS.

$$(10^5 \times 10^3)^3 = 10^{5 \times 3} \times 10^{3 \times 3} = 10^{15} \times 10^9 = 10^{24}$$

POWER OF A FRACTION EQUALS THE POWER OF THE NUMERATOR DIVIDED BY THE POWER OF THE DENOMINATOR

$$\left(\frac{10^6}{10^3}\right)^2 = \frac{10^{6 \times 2}}{10^{3 \times 2}} = \frac{10^{12}}{10^6} = \frac{10^{-6}}{10^{-6}} = 10^{0}$$

THE ROOT OF A POWER.

RULE → TO GET THE ROOT OF A POWER DIVIDE THE EXPONENT BY THE INDEX OF THE ROOT.

$\sqrt[2]{25\times10^{8}} = {}^{10^4}\sqrt{5} = 5\times10^{4}$

$\sqrt[2]{10^{4}} = {}^{4\div2=10^{2}}\sqrt{10}$

$\sqrt{(400)^2+(300)^2} = \sqrt[2]{(4\times10^4)^2+(5\times10^4)^2} = \sqrt{(4\times4\times10^4)+(5\times5\times10^4)} =$

$= \sqrt{(16\times10^4)+25\times10^4} = \sqrt{41\times10^8} = {}^{10^4}\sqrt{6.43}$

IN NUMBERS $= \sqrt{5600}$ = DOES NOT MAKE IN TO A NUMBER FROM 1-TO-10 THE EXPONENT CAN-NOT BE EVENLY DIVIDED.

$\sqrt{5.6\times10^3} = {}^{10^{1/2}}\sqrt{5.6}$

MULTIP. & DIVIS. OF SIGNS.

RULE → LIKE SIGNS WILL BE POSIT. +

UN-LIKE " " NEG. −

THUS: $(a^{-5})^{3} = a^{-30}$ $(a^{-5})^{-6} = a^{-30}$

LOGARITHMS

DEFINITION → A LOGARITHM IS THE EXPONENT OF THE POWER TO A GIVEN BASE. BASE OF 10 MOSTLY USED

EXAMPLE = $10^3 = 10 \times 10 \times 10 = 1000$ - 3 IS THE EXPONENT OF THE BASE 10. 3 IS THE LOG OF 1000 TO THE BASE 10 WRITTEN IN LOGRITHMIC FORM = $3 = \log_{10} 1000$ OR $\log 1000 = 3$ TEN IS BEING USED, THE NUMBERS DO NOT HAVE TO BE WRITTEN - $\log 1000 = 3$

IN $a^x = b$, X IS THE LOG OF THE NUMBER b TO THE BASE a. $\log_a b = x$

EXPONENTIAL FORM = $a^x = b$

LOGRITHMIC FORM = $\log_a b = x$

THE LOG OF A PRODUCT (MULTIPLICATION)

RULE → THE LOG OF A PRODUCT = THE SUM OF THE LOGS OF THE FACTORS

LAWS OF EXPONENTS → $a^3 \times a^2 = a^{3+2} = a^5$

IF $a^3 = M$, AND $a^2 = N$ THEN $\log_a M = 3$ AND $\log_a N = 2$

SINCE $M \times N = a^3 \times a^2 = a^5$; THEN $\log_a M + \log_a N$

THIS CAN BE DONE WITH MORE FACTORS.

THE LOG OF A QUOTIENT (DIVISION)

RULE → THE LOG OF A QUOTIENT = THE LOG OF THE DIVIDEND MINUS THE LOG OF THE DIVISOR.

LAW OF EXPONENTS → $a^3 \div a^2 = a^{3-2} = a^1 = a$

IF $a^3 = M$; AND $a^2 = N$ THEN $\frac{M}{N} = a^3 \div a^2 = a$

SINCE THE $\log_a M = 3$ AND $\log_a N = 2$

THEN $\log_a M - \log_a N = 1$

LOG OF A POWER

RULE → THE LOG OF A POWER = THE LOG OF THE NUMBER TIMES THE EXPONENT OF THE POWER.

LAW OF EXPONENTS → $a^x = (a^3)^2 = a^{3 \cdot 2}$

IF $a = a^3$ THEN $a^x = a^{1 \cdot 2}$

THE LOG OF A ROOT

RULE → THE LOG OF A ROOT = THE LOGARITHM (LOG) DIVIDED BY THE INDEX OF THE ROOT

$\sqrt[2]{M} = a^{\frac{3}{2}}$ (Log$_a$ M ÷ 2)

LAW OF EXPONENTS → (FRACTIONAL EXPONENT)

Log M ÷ 2

$\sqrt{M}$ = Log$_a$ M ÷ 2

ANOTHER: $\sqrt[3]{625^2} = 625^{\frac{2}{3}}$ OR

Log 625 = 2.7959 ∴ $\frac{2}{3} \times 2.7959 = \frac{2 \times 2.7959}{3}$

RULE ⇒ IF LOGARITHMS ARE USED FOR COMPUTATIONS INSTEAD OF NUMBERS, THEN MULTIPLICATION, DIVISION, RAISING TO POWERS AND EXTRACTING ROOTS BECOME ADDITION, SUBTRACTION, MULTIPLICATION & DIVISION. BY THE LAW OF EXPONENTS.

RULE → EVERY POSITIVE NUMBER MAY BE EXPRESSED AS A POWER OF SOME BASE

CHARACTERISTICS

$10^4 = 10{,}000$

$10^3 = 1000$

$10^0 = 1$

$10^{-1} = .1$

$10^{-2} = .01$

$10^{-3} = .001$

BETWEEN 1 AND .2; AND INT 1 TO 10 BETWEEN
2 TO 1 OR A DECIMAL. THE CHARACTERISTIC CAN
BE SEEN BY LOOKING AT THE NUMBER. THE DECIMAL
POINT OF THE MANTISSA [illegible]

RULE → THE CHARACTERISTIC OF A LOG OF A NUMBER GREATER THAN
1 IS POSITIVE AND IS ONE LESS THAN THE NUMBER OF
DIGITS TO THE LEFT OF THE DECIMAL POINT.
EXAMPLE: $682. = 6.82 \times 10^2$ ·CHARACTERISTIC .2

RULE → THE CHARACTERISTIC OF THE LOG OF A NUMBER LESS THAN
1 IS NEGATIVE AND IS ONE MORE THAN THE NUMBER OF
ZEROS TO THE RIGHT OF THE DECIMAL POINT.
EXAMPLE: $.00425 = 4.25 \times 10^{-3}$; CHARACTERISTIC -3
TO GET A LOG [illegible]
-3 MAY BE [illegible]
$-10 + 7 = -3$ [illegible]

RULE → THE MANTISSA OF A LOG IS NOT AFFECTED BY THE SHIFT
OF THE DECIMAL POINT IN THE NUMBER - ONLY THE CHARACTERISTIC CHANGES.
EXAMPLE: [illegible]
OF THE FOLLOWING NUMBERS.
[illegible]
[illegible]

TABLES OF LOGS

TO FIND THE MANTISSA OF THE LOG OF A NUMBER,
IT CONSIST OF 11 COLUMNS
NUMBERS 0 TO 1000.
THE FIRST COLUM "N" INDICATES THE FIRST TWO DIGITS
OF [illegible]
AND THEY INDICATE THE THIRD DIGITS OF THE NUMBER. EXAMPLE 485 - 48 IS FOUND IN COLUM "N" AND THE 5 ON COLUM 5. IN THE COLUMS
FROM 0 TO 9 THE [illegible]
EXAMPLE: [illegible]

THE 5 COLUM INTER[illegible] AND
THIS NUMBER IS THE MANTISSA = .0857 SO THE
Log OF 485 = 2.6857.

RULE → ALWAYS WRITE THE CHARACTERIS[illegible]
IF THE EXACT NUMBER IS NOT IN THE
INTERPOLATION IS THE NEXT STEP.

EXAMPLE: FIND LOG OF 4347.
CHARACTERISTIC = 3.
NUMBER IN 'N' COLUM 43.
MANTISA BETWEEN COLUM 4 AND 5.
FIND TWO CLOSEST MANTISMS.
UNDER COLUM 5 = .6385 (4350)
" " 4 = .6375 (4340
[illegible]
SO A INCREASE OF NUMBER BY 10 IT INCRE[illegible]
[illegible]
HENCE THE INCREASE WILL BE .0010 X .7 = .0007
AND THE MANTISA OF 4347 = 3.637 + .0007 = 3.6382

RULE → FOR A NUMBER CONSISTING OF MORE THAN THREE FIGU
FIND THE MANTISA OF THE [illegible] THREE NUMBER
AND ADD TO THIS THE TABULAR DI[illegible] TIMES T
[illegible] OF THE LAST FIGURE USED AS
DECIMALS.

[illegible]
EXAMPLE: Log 872 = 2.9405 ∴ ANTILOG 2.9405 = 872

TO FIND THE ANTILOG ON THE TABLES REVERSE THE
PROCESS GIVEN TO FIND THE LOG, AND REMEMBER THE
CHARACTERISTIC REPRESENTS THE PLACE OF THE DECIMAL
POINT.
EXAMPLE: FIND ANTILOG OF 3.9101. FIND IN FIGURE
THE POSITION OF MANTISSA .9101 AND WRITE NUMBER
COLUM "N" = 81 AND NUMBE OF COLUM = 2. SINCE THE CHA
TERISTIC WAS 3 THE NUMBER IS 8130

THE LOG WAS 0.9101 THE NUMBER - 5.13
" " " 7.9101-10 " " = .00813

TO INTERPOLATE
EXAMPLE FIND
FIND THE TWO CONSECUTIVE MANTISSAS BETWEEN THE
GIVEN. THEY ARE - .3674 & .3692. THOSE CONSIDE

	.3692	MANTISA OF 234
	-.3674	" " -233
DIFF.	.0018	001

THE SMALLEST .3680 - .3674 = .0006 THEN THE
REQUIERED NUMBER IS. $\frac{.0006}{.0018} \times 1 = .33$

.33 ADDED TO THE SMALLEST NUMBER = 233.33

MULT. COMPUTATIONS BY LOGS
EXAMPLE: FIND PRODUCT OF 684 X 2.79
PRODUCT = ANT LOG 684 + LOG 2.79
Log 684 = 2.8351 Log 2.79 = 0.4466
2.8351 + 0.4466 = 3.2807
ANTILOG 3.2807 = 1908

DIV. FOR DIVISION SUBTRACT THE LOGS AND FIND THE ANTILOG

FIND THE VALUE OF $(.0563)^5$
$\log (.0563)^5 = 5 \log .0563$
$\log .0563 = 8.7505 - 10$
$\times 5$
$5 \log .0563 = 43.7525 - 50$
$= 3.7525 - 10$

ANTI LOG $3.7525 - 10 = 5.656 \times 10^{-7}$

FIND VALUE OF $\sqrt[3]{815}$
$\sqrt[3]{815} = (815)^{\frac{1}{3}} = \frac{1}{3} \log 815$
$\log 815 = 2.9112$
$\frac{1}{3} \log 815 = \frac{2.9112 \times 1}{3} = .9704$

ANTILOG .9704 = 9.34

EVALUATE $X = \frac{64.28 \times .0973}{\sqrt{4006}}$

$\text{Log } X = \text{Log } 64.28 + \text{Log } .0973 - \frac{1}{2}\text{Log } 4006$

$\text{Log } 64.28 = 1.8078$

$\text{Log } .0973 = \underline{\quad 2.9881 - 10}$

$\quad\quad 10.7959 - 10$

$\text{Log } 4006 = 3.6034$

$\text{Log } X = 8.1925 - 10 \quad \text{or} \quad .0925$

RULE → SUBTRACT THE LOG 6.9860 FROM 4.1073.
SINCE THE SUBTRAHEND IS LARGER THAN THE MINUEND
ADD 10 TO THE CHARACTERISTIC OF THE MINUEND AND
WRITE −10 AFTER THE MANTISSA.

$4.1073 = 14.1073 - 10$

$\underline{6.9860}$

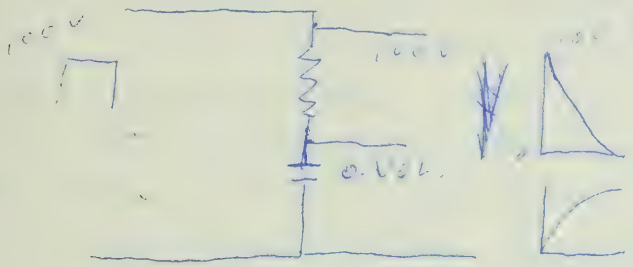
$7.1213 - 10$

RULE → DIVIDE THE LOG 8.4756 − 10 BY 3.
IN ORDER FOR THE QUOTIENT TO RETAIN −10
IT IS NECESSARY TO CHANGE −10 TO −30 BY ADDING −20 TO
THE −10 AND ALSO ADDING 20 TO ITS CHARACTERISTIC 8

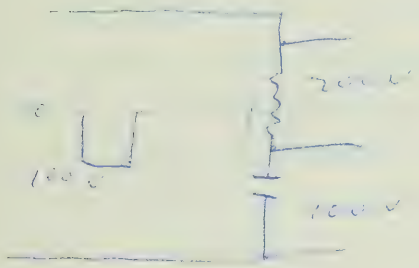
$8.4756 - 10 = 28.4756 - 30$

$(28.4756 - 30) \div 3 = 9.4919 - 10$

AT THE INSTANT OF THE ALTERNATION CHANGE THE VOLTAGE ACROSS THE R. CAN BE TWICE THE IN PUT VOLT. WHITH THE CAP. FULLY CHARGE WHEN THE INPUT CHANGE = POLARITY THE VOLT. IN THE CAPACITOR WILL ADD TO THE INPUT THEREFORE ADDING ACROSS THE R.



INSTANTANEOUS VOLT.



INSTANTANEOUS VOLT.
AT CHANGE OF ALT.

CAP. IN SERIES ADD RECIPROCAL METHOD
CAP " PARR. ADD.
CAP IN SERIES ADD W.V.D.C

DIFFERENTIATING & INTEGRATING

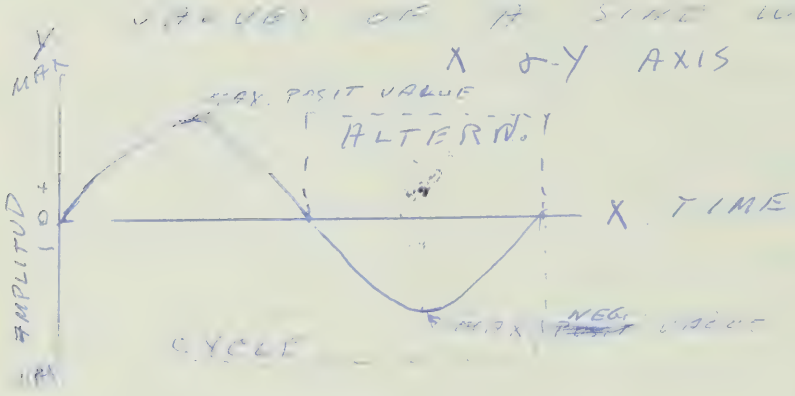
TAKING THE VOLT. ACROSS R. = DIFFERENTIATING.
TAKING " " " C. = INTEGRATING.

OSCILLOSCOPE (USE OF)

A.C VISUAL VOLTMETER.

IT WILL MEASURE A.C. VOLTS IN THE SCREE

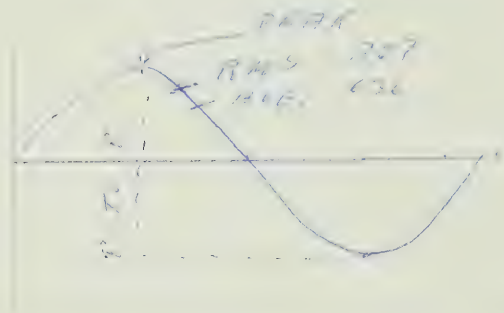
VALUES OF A SINE WAVE.



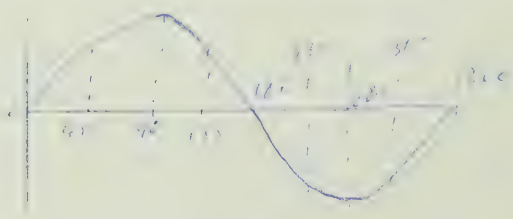
FR. CYCLES PER SECON

SINE WAVE ~~[illegible]~~ IS
THE FUNCTION OF THE S
RATIO.

RULE → EFFECTIVE VALUE = R.M.S = .707 X MAX.
PEAK VALUE = 1.414 X RMS = MAX.
AVERAGE VALUE = .637 X MAX.
PEAK TO PEAK = 2 X MAX.
R.M.S OR 70.7 % OF PEAK = EQUIEVALENT D.C VOLTS.



Y AXIS - VERTICAL
X - AXIS - HORIZONTAL



SCOPE WILL MEASURE THE PEAK TO PEAK VOLT.
SCOPE MUST BE CALIBRATED TO A KNOWN VOLT.

THE OSCILLOSCOPE GIVES THE GRAPH OF A SINE WAVE.

CONTROLS:

INTENSITY: CONTROLS THE GRID VOLTAGE.

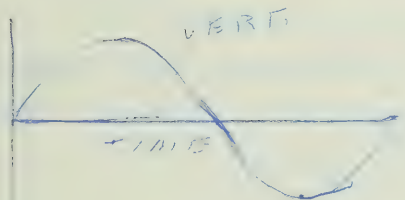
FOCUS: VARIES VOLTAGE BETWEEN FOCUSING ANODES.

VERTICAL & HORIZONTAL POSITION:
VARIES POTENTIAL AT DEFLECTION PLATES. THESE PLATES CONTROL THE ELECTRON BEAM BY CHANGING THE POSIT. OR NEG. POTENTIAL [illegible]

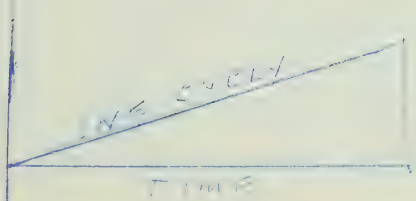
COARSE & FINE FR. CHANGES FR. OF SWEEP.

SYNC. CONTROL. SYNCRONIZES INPUT WAVE WITH THE SWEEP TO STOP PICTURE.

HORIZONTAL LINE - TIME - X-AXIS
VERTICAL LINE - AMPLITUDE - Y AXIS - INPUT SIGNAL



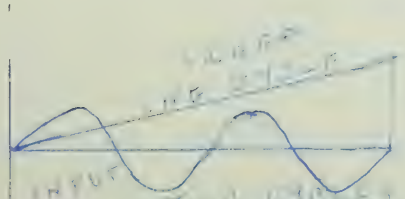
COARSE FR. TIMEBASE FR.



HORIZONTAL SWEEP RATE.

TO OBSERVE ONE CYCLE OF INPUT FR. THE SWEEP FR. MUST BE THE SAME.

TO OBSERVE 2 CYCLES $\frac{1}{2}$ THE INPUT FR.
" " 3 " $\frac{1}{3}$ " " "



CHECK JOB SHEETS FOR MORE

VACUUM TUBES.

THERMIONIC EMISSION.
IF HEAT IS APLIED TO A METAL IT WILL GIVE ELECTRONS.

EMITERS- TUNGSTEN — THORIATED-TUNGSTEN AND OXIDE-COATED.

DIRECTLY & INDERECTLY HEATED EMITERS

DIRECTLY HEATED CATHODES ARE MORE EFFICIENT

DIODES

PLATE, CATHODE AND HEATER.

WHEN CATHODE IS HEATED IT EMITES ELECTRONS
THE PLATE IS POSITIVE WITH RESPECT TO CATHODE.
SO ELECTRONS WILL FLOW FROM CATHODE TO PLATE.

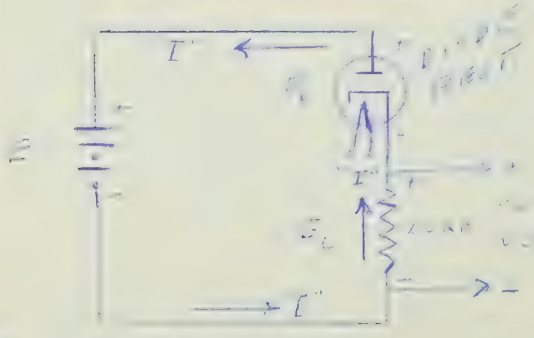
THE MORE POSITIVE THE PLATE BECOMES THE MORE ELECTRONS WILL FLOW, UNTIL THE POINT OF SATURATION.

A.C PLATE RESISTANCE = $\frac{\text{PLATE 'E'}}{\text{PLATE 'I'}} = R_p = \frac{E_b}{I_b}$

THIS IS ONLY FOR RESISTANCE OFFERED TO D.C NOT TO A.C WHICH IS ALSO PRESENT.

USES OF A DIODE = AS RECTIFIER AND DETECTOR

RECTIFIER.

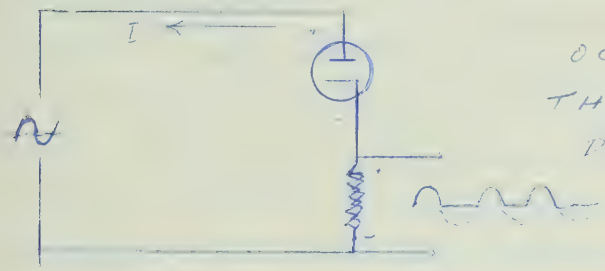


IS THE CURRENT FLOW IN THE EXTERNAL CKT RESISTOR IT DEVELOPS A VOLTAGE THIS VOLTAGE IS THE OUTPUT VOLTAGE IN THE CKT.
THE OUTPUT VOLTAGE PLUS THE VOLTAGE DROP IN THE TUBE MUST EQUAL THE SOURCE.

$E = E_L + E_T$

RECTIFICATION

A DIODE CONECTED TO AN A.C. SUPPLY, WILL CONDUCT ONLY ON THE POSITIVE ALTERNATION SO THE OUT PUT WILL BE PULSES OF CURRENT



OUTPUT OF A DIODE.
THE CURRENT WILL FLOW IN ONE DIRECTION SINCE THE TUBE CONDUCTS IN THE POSITIVE ALTERNATION ONLY.

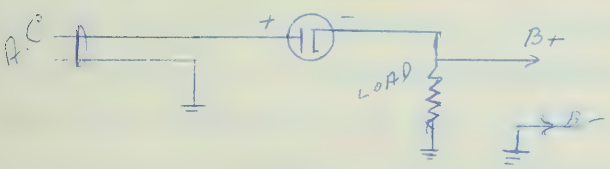
RECTIFICATION AND FILTERING.
A RECTIFIER CHANGES A.C TO D.C.

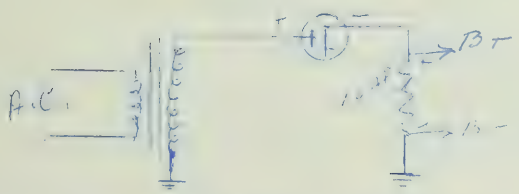
POWER SUPPLIES

HALF WAVE, FULL WAVE AND BRIDGE RECT

HALF WAVE- ALTERNATION.

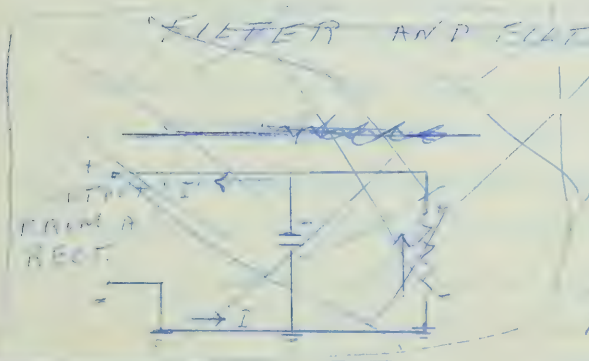
CURRENT FLOWS ONLY IN THE POSITIVE
A TRANSFORMER MAY BE USED TO STEPUP THE VOLTAGE TO THE PLATE.





THE OUTPUT VOLTAGE OF A RECTIFIER MUST BE FILTERED BEFORE IT CAN BE USED.
OUTPUT OF A HALF WAVE RECTIFIER.

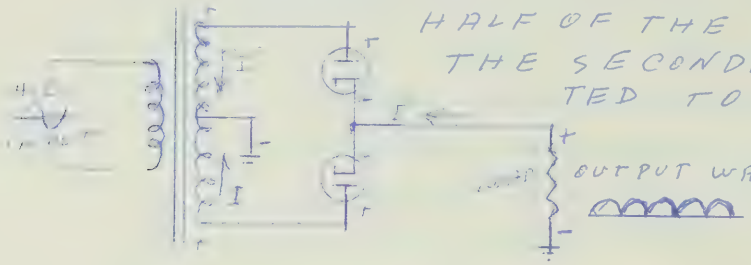
THE FR. OF THE RIPPLE IS THE SAME AS THE FR. OF THE INPUT VOLTAGE WAVE.



HALF WAVE RECTIFIERS HAVE THREE DISADVANTAGES.

1. THE A.C. RIPPLE IS TO HARD TO FILTER OR SMOOTH OUT.
2. THE A.C. SUPPLY IS FURNISHING POWER ONLY HALF OF THE TIME SO THE [illegible] IS LESS, AS COMPARED TO THE FULL WAVE LOAD.
3. IF IT USES A XFORMER THE D.C. PULSES MAY SATURATE IT

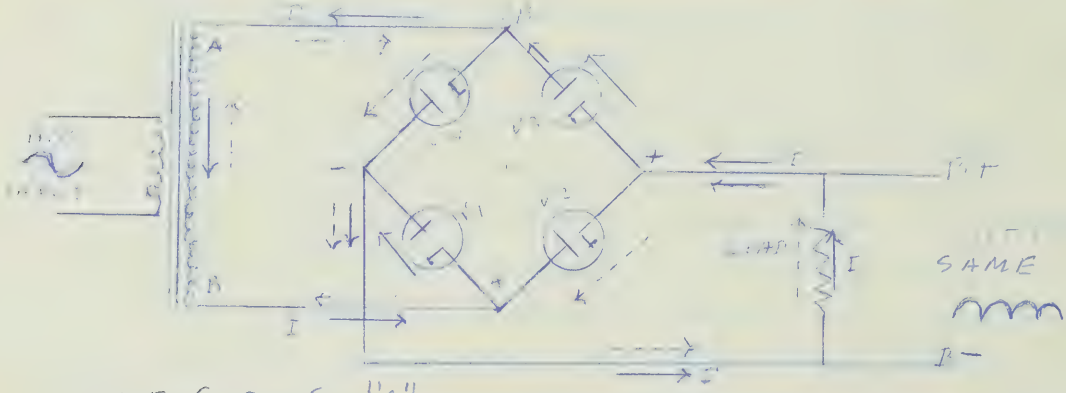
FULL WAVE RECTIFIER.



IN XFORMER ACTION ONE SIDE WILL POSITIVE AT EACH HALF OF THE INPUT CYCLE. BY HAVING THE SECONDARY CENTER TAPED AND CO TED TO THE CATHODE THROUGH TH LOAD. WHEN ONE SI OF THE XFORMER GOES POSITIVE THAT TUBE WILL CONDUCT, WHILE THE OTHE ONE WONT, BEING MORE NEGATIVE THAN IT'S CATHOD IN THE NEGATIVE SIDE OF THE INPUT WAVE THE PO RITY IN THE SECONDARY REVERSES AND THE OTHER TUBE BECOMES POSITIVE AND CONDUCTS.

THE OUTPUT RIPPLE HAS TWICE THE IMPUT FR. THEREFORE, IS MUCH EASIER TO FILTER. THE FULL WAVE IS MORE EFFICIENT THAN THE HALFW

BRIDGE RECTIFIER (FULL WAVE)



WHEN POINT "A" BECOMES POSITIVE ON POSITIVE HALF OF CYCLE, THE SECONDARY VOLTAGE IS ACROSS V1, THE LOAD AN V3 — V1 & V3 ARE CONDUCTING. (SOLID ARROWS.) PLATES OF V3 & V1 ARE MORE POSITIVE THAN THEIR CATHODES SO THEY CONDUCT V2 & V4 DON'T CONDUCT BECOUSE THEIR PLATES ARE NEGATIV ON THE NEGATIVE SIDE OF CYCLE POINT "B" BECAMES POSITIVE, THE SECONDARY VOLTAGE IS NOW ACROSS, V2, V4 & THE LOAD, V2 & V4 ARE NOW CONDUCTING. (DOTTED ARRO

THE OUTPUT RIPPLE FR. IS TWICE THE INPUT FR. THE BRIDGE IS MORE EFFICIENT THAN THE FULL WAVE SINCE THE XFORMER IS NOT CENTER TAPPED, THE FULL VOLTAGE ACROSS THE SECONDARY IS USED, THEREFOR THE OUTPUT VOLTAGE IS DOUBLED

PRESENTS A PROBLEM WITH THE FILAMENT SUPPLY. THREE SEPARATE FILAMENT XFORMERS ARE NEEDED THE FILAMENTS OF V_2 & V_3 ARE OF THE SAME POTENTIAL BUT THE FILAMENT OF V_1 IS AT DIFFERENT POTENTIAL FROM EITHER V_4 OR V_2. THE XFORMERS MUST BE INSULATED FROM EACH OTHER & GROUND.

BRIDGE'S ARE USED AS HIGH VOLTAGE SUPPLY HIGH DRAIN.

INSTEAD OF DIODE TUBES METALIC RECTIFIERS CAN BE USED IN POWER SUPPLIES.

THE MOST COMMONLY USED IS THE SELENIUM RERTIFIER.

THIS RECTIFIER IS COMPOSED OF PLATES WITH A COATING OF SELENIUM IN ONE SIDE.

THEY HAVE THE PROPERTY OF PASSING CURRENT ONE WAY ONLY. THE SELENIUM OFFERS HIGH RESISTANCE TO CURRENT FLOW.

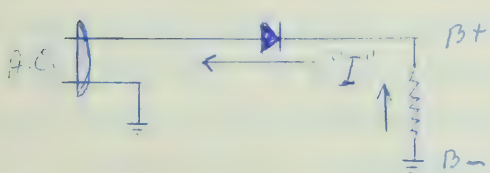
VERY HIGH "R" ONE WAY, NO "R" THE OTHER WAY. ALSO CALLED SEMI CONDUCTORS.

SYMBOL

THE ARROW POINT IS THE PLATE AND THE FLAT THE CATHODE.

THE ONLY TIME IT WILL PASS "I" IS WHEN IT IS FLOWING AGAINST THE ARROW.

THEY CAN BE USED AS IN PLACE OF TUBES



THE SELENIUM HALF WAVE RECT. IS NOT USED TOO MUCH BECAUSE IT CAN'T STAND VERY LARGE VOLTAGE. (PEAK INVERSE)

ANOTHER DISHOVANTAGE IS THE CURRENT RATING IS SMALL. USALLY ABOUT 75 TO 100 MILIAMPS.

ALSO- LOW PEAK INVERSE VOLTAGE.

BACKWARD RESISTANCE DECREASES WHEN THE TEMPERATURE INCREASES.

THE SIZE OF THE PLATES DETEMINE THE AMOUNT OF CURRENT IT CAN PASS.

RATED AT 35 VOLTS PER PLATE. THEY USUALLY HAVE 4 PLATES.

POLARITY MUST BE OBSERVE WHEN USING IN A CKT. THEY ARE MARKED IN ONE SIDE WITH A + SIGN THIS IS THE CATHODE OR B+ SIDE.

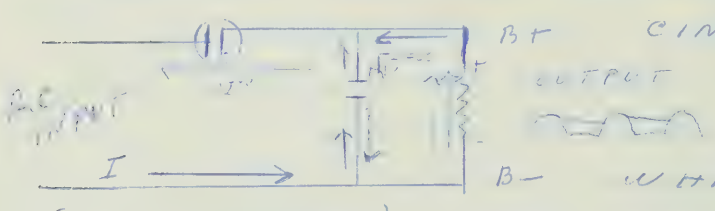
SELENIUM ARE USED MOSTLY IN BRIDGE CKTS.

TO CHECK IF A SELENUM REC IS GOOD OR NO THE PROPER WAY IS TO PUT ONOTHER ACROS AND CHECK THE OUTPUT VOLTAGE.

FILTER CKTS FOR POWER SUPPLIES

THE OUTPUT OF ANY RECTIFIER POWER SUPPLIE IS OF THE SAME POLARITY (D.C.) BUT IT HAS A PULSATING A.C COMPONENT WHICH MUST BE SMOOTHED OUT BEFORE IT CAN BE USED. THIS IS DONE BY FILTERING. VARIOUS METHODS MAY BE USED. AT THIS TIME THE CAPACITOR—RESISTOR WILL BE USED.

FILTER ACTION CAN BE OBTAIN BY MERELY PLA BY PASSING AN ELECTROLITIC CAP. ACROSS THE LOAD.

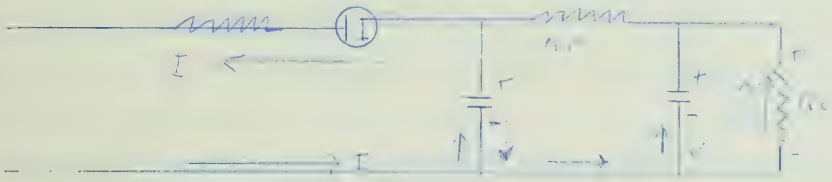


WHEN THE TUBE CONDUCTS (SOLID ARROWS) THE CAPACITOR IS CHARGED AS PART OF THE CURRENT FLOWS IN AND PART ACROSS THE LOAD IN THE SECOND HALF OF THE CYCLE THE TUBE WILL NOT PASS "I" SO THE CAPACITOR DISCHARGES ACROSS THE LOAD THEREFORE FILLING IN SOME OF THE RIPPLE OF THE WAVES.

THE CAPAC. IS USUALLY LARGE ENOUGH SO THAT IT DOES NOT HAVE TIME TO DISCHARGE COMPLETELY BEFORE THE NEXT CYCLE BEGINS. SINCE THE VOLTAGE ACROSS THE CAP. IS NOT QUITE REACHED CERT, THE TUBE WILL NOT CONDUCT UNTILL THE POTENTIAL ON THE PLATE PASSES THAT ON THE CAP. THAT IS

THE PLATE BECOMES MORE POSITIVE THAN THE CATHODE AT THE POINT OF THE WAVE WHERE THE VALUE EXCEEDS THAT OF THE CAP. THEN AS THE ALTERNATION CONTINUES THE TUBE CEASES TO CONDUCT WHEN THE APPLIED VOLT. DROPS BELOW THE CONDENSER VOLTAGE. THESE PEAKS OF PLATE CURRENT MAY BE QUITE HIGH IF THE CONDENSER IS HIGH AND THE LOAD "R" SMALL. IF THE LOAD CURRENT IS SMALL THE CAP. WILL DISCHARGE SLOWLY AND IF IT IS LARGE IT WILL DISCHARGE MUCH FASTER. A HIGH LOAD "R" MEANS SMALL LOAD CURRENT.

THE RIPPLE VOLTAGE CAN'T BE ELIMINATED COMPLETELY BY A CAPACITOR SO MORE ELEMENTS MUST BE ADDED TO THE FILTER.



IN THIS TYPE OF FILTER THE OUTPUT HAS HARDLY NO RIPPLE. THE FIRST CAP. ACTS IF IT WAS BY HIMSELF. THE FILTER "R" TENDS TO OPOSE THE RIPPLE FROM GOING THROUGH AND IT FORCES IT TO GO THROUGH THE LAST CAP. THEREFORE ELIMINATING MOST OF THE RIPPLE TO PASS THE LOAD.

THIS TYPE OF FILTER IS MOSTLY USED WHEN LOAD CURRENTS ARE SMALL. THE CAPACITOR CHARGES AT PEAK VOLTAGE. IF THE LOAD INCREASES THE VOLTAGE DROPS BECAUSE THE CURRENT DISCHARGES THE CAP. FROM ITS CHARGE.

A DISADVANTAGE OF CAPACITOR INPUT FILTER IS THE HEAVY CURRENT DRAWN BY THE CAP. TROUGH THE RECTIFIER. THE CHARGING CURRENT PLUS THE LOAD CURRENT MAY DAMAGE THE TUBE. TO PREVENT THIS A RESISTOR IS PLACED ON THE PLATE CKT TO LIMIT THE CURRENT.

BUT IT IS NOT ADVISABLE TO USE THIS TYPE OF FILTER WITH MERCURY VAPOR TUBES. THE HEAVY RUSH OF CURRENT CAN DAMAGE THE CATHODE.

A CAPACITOR INPUT FILTER WITH NO LOAD PRODUCES A TERMINAL VOLTAGE WHICH NEARLY EQUALS THE PEAK VOLTAGE OF THE APLIED VOLTAGE ALSO THE CAP. WILL BE CHARGED TO THE PEAK VOLTAGE WITHING A FEW CYCLES.

THE RESISTOR-CAP. FILTER IS NOT USED WHERE A NEED FOR A BIG LOAD CURRENT IS REQUIERED, BECAUSE. THE EXCESSIVE VOLTAGE DROP THAT TAKES PLACE ACROSS THE FILTER RESISTOR.

IN DESIGNING A POWER SUPPLY, CARE MUST BE TAKING IN USING COMPONENTS NOT TO EXCEED THE RATED VALUE GIVEN FOR THE TUBE USED FOR EXAMPLE:

THE MAXIMUM PEAK CURRENT OF THE TUBE MUST NOT BE EXCEED. THIS IS THE MAXIMUM CURRENT WHICH THE TUBE IS ALLOWED TO PASS WHEN CHARGING THE CAP. THE VALUE OF THIS CAP. MUST BE TAKEN IN CONSIDERATION (NOT TOO LARGE)

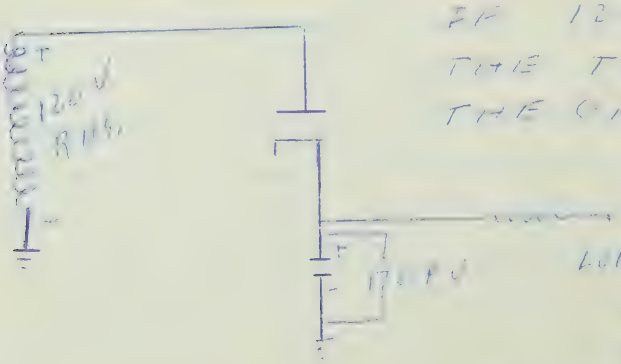
ALSO THE MAXIMUM PEAK INVERSE VOLTAGE MUST BE TAKEN IN CONSIDERATION.

PEAK INVERSE VOLTAGE IS THE MAXIMUM VOLTAGE THAT CAN BE APPLIED TO THE TUBE IN THE OPPOSITE DIRECTION (PLATE NEGATIVE)

THE PEAK INVERSE VOLTAGE CAN BE TWICE THE APLIED PEACK VOLTAGE.

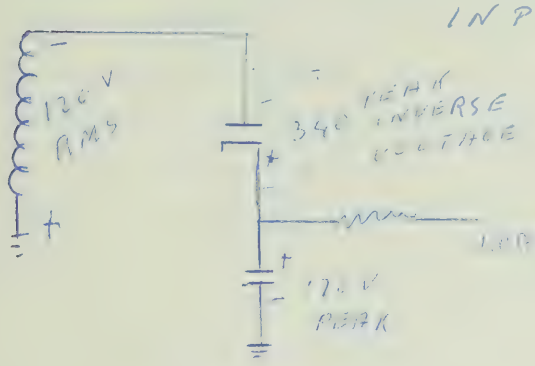
IF 120 V R.M.S. ARE APLIED TO THE TUBE, WITHIN A HFEW CYCLE THE CAP. WILL BE CHARGE TO PEAK VOLTAGE OR

120 X 1.414 = 170 P.V



WHEN THE CAPACITOR IS FULLY CHARGE AND THE CYCLE REVERSES. (PLATE NEGATIVE) AT THAT INSTANT, BEEN

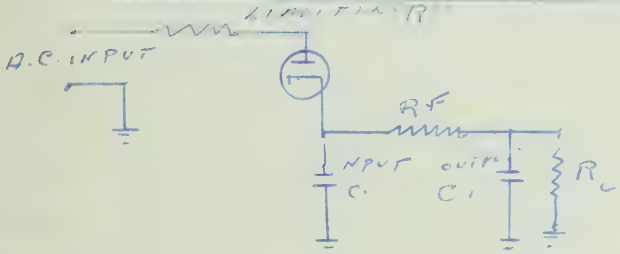
THE CAPACITOR DISCHARGES THROUG THE LOAD AND SINCE THE TUBE IS NOT CONDUCTING THE INPUT VOLTAGE WILL ADD TO THE CAPACITOR VOLTAGE GIVING US 340 VOLTS BETWEEN THE PLATE AND CATHODE WHICH THE TUBE MUST BE ABLE TO TAKE, OR IT WILL ARC OVER AND BURN.



FULL WAVE POWER SUPLIES ARE MUCH EASIER TO FILTER BECAUSE THE RIPPLE FR. IS TWICE THE HALF WAVE FR.

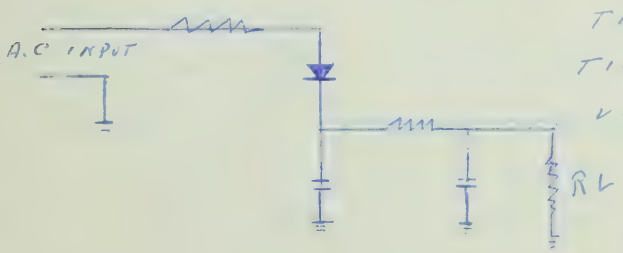
DIFFERENT POWER SUPPLIES APPLICATIONS AND USES.

THE HALF WAVE (TUBE)



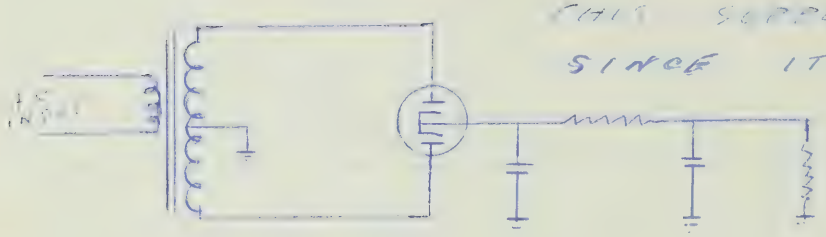
THIS TYPE OF SUPPLY USED FOR LOW CURRENT LOADS. TOO HARD TO FILTER. THE A.C COMPONENT IS OF THE SAME INPUT FR. [illegible] OF THE INPUT WAVE IS USED.

HALF WAVE (SELENIUM)



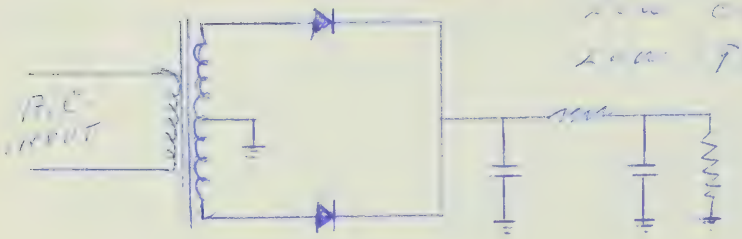
THIS TYPE IS NOT TOO PRACTICAL. THE PEAK INVERSE VOLTAGE OF THE SELENIUM IS VERY LOW. ALSO IT [illegible] ONE ADVANTAGE IS THAT NO TRANS FORMER IS NEEDED. (FILAMENT)

FULL WAVE (TUBE)



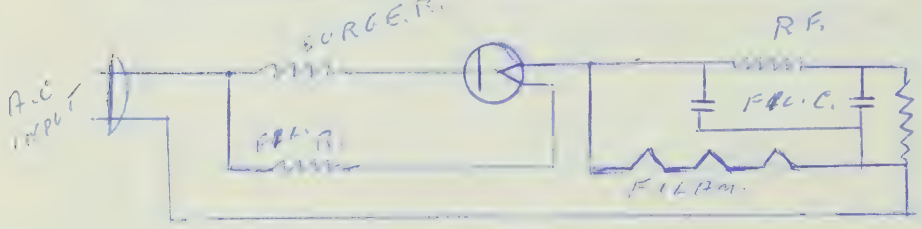
THIS SUPPLY IS MORE EFFICIENT
SINCE IT USES BOTH SIDES OF T
CYCLE ALSO THE
RIPPLE FR. IS TWICE
INPUT FR. SO IT IS
TO FILTER.

FULL WAVE (SELENIUM).



LOW CURRENT RATING
LOW PEAK INVERSE VOLTAGE.
NO FILAMENT SUPLY

A.C. D.C. HALF WAVE SUPPLY W/ FILAMENT SUPLY



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THIS TYPE O
SUPPLY ELIMI-
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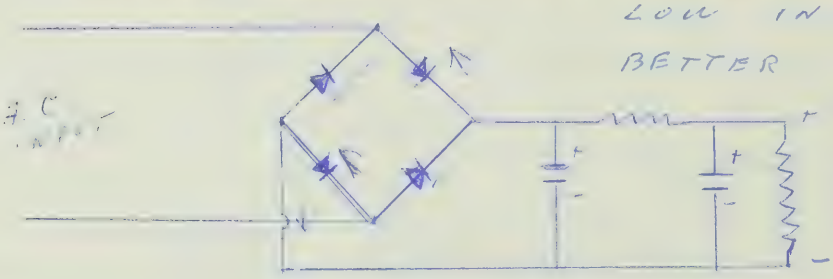
BRIDGE RECTIFIER (SELEN.)

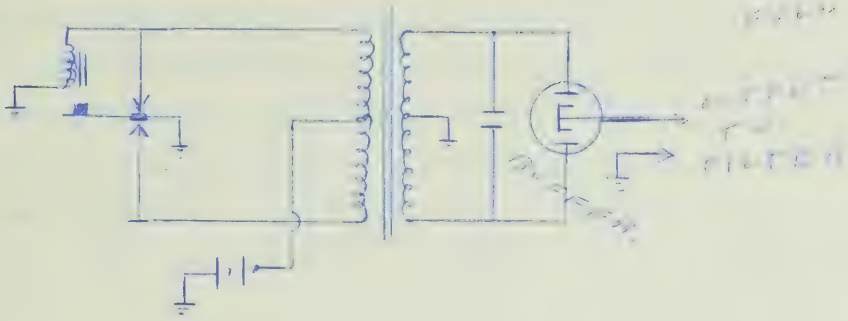


FULL WAVE
LOW INVERSE VOLTAGE.
BETTER THAN HALF WAVE. IN
VOLTAGE DIVIDES
TWEEN TWO RECT.
GOOD NO NEED FO
FILAMENT XFORMERS

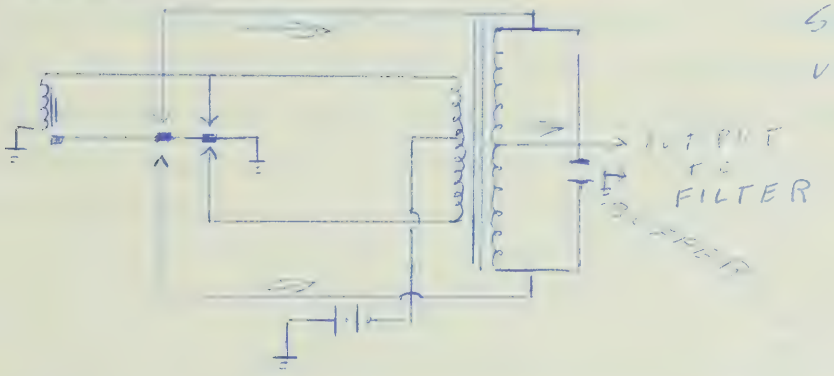
LARGE AMOUNT OF D.C. USED IN METERS.

VIBRATOR POWER SUPPLIES

NON-SYNCRONOUS.



SYCRONOUS VIBRATOR



SYNCRONOUS VIBRATOR,

RIPPLE FR. ABOUT 230 C.P.S.

VIBRATOR PRODUCE LOW D.C VOLTAGE TO HIGH D.C. VOLTAGE BY USING STEP-UP XFORMERS.

IN THE NON-SYCRONOUS VIBRATOR THE REED PERIODICALLY INTERRUMPS THE FLOWING IN THE PRIMARY AND REVERSES THE DIRECTION, INDUCING A VOLTAGE (A.C) IN THE SECONDARY. THIS A.C MUST BE RECTIFIED AND FILTERED.

IN THE SYNCRONOUS VIBRATOR BY TAKING THE OUTPUT IN THE CENTER TAPED SECONDARY AND HAVING THE ENDS OF THE SECONDARY TO THE RECTIFIER OF CONTACT AND THE REED GROUNDE WILL HAVE A PULSATING D.C OUTPUT FROM THE CENTER TAPED TO BE FILTERED.

THE FR. OF THE MOST USED VIBRATOR IS AROUND 115 C.P.S.

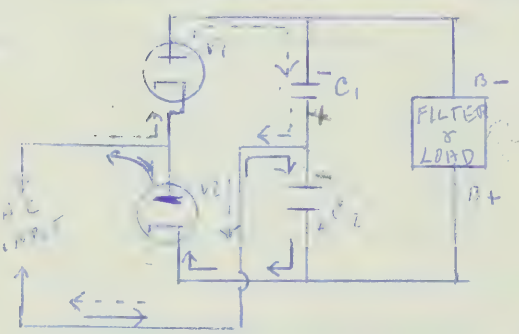
THE BUFFER CAP. ACROSS THE SECONDARY I TO COUNTER BALANCE THE CEMF PEAKS WHEN THE REED BREAKS CONTACT. THESE PEAKS

OF CEMF MAY ARC ACROSS THE CONTACTS MAKING THE STICK. AND BURN OUT THE VALUE IS QUITE CRITICAL. IF IT IS TO GREAT IT PLACES A BIG LOAD IN THE XFORMER. AND IF IT IS NOT BIG ENOUGH IT DOESNT REDUCE THE PEAKS. AVERAGE VOLTAGE FROM THIS TYPE RECTIFIER AT BETWEEN 1500 TO 3000 VOLTS DUE TO THE HIGH VOLTAGE PEAKS.

VOLTAGE DOUBLER

A VOLTAGE DOUBLER IS A CKT IN WHICH TWO CAP. ARE CHARGED IN ALTERNATE HALF CYCLES AND SO ARRANGED THAT THE VOLTAGES ON THE TWO CAP. ADD IN THE OUTPUT. SUCH A CKT. CAN DELIVERED A VOLTAGE WHICH IS TWICE THE PEAK OF THE APLIED VOLTAGE

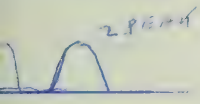
FULL WAVE VOLTAGE DOUBLER.

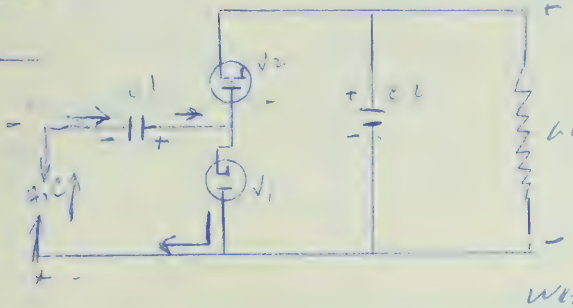


WHEN PLATE OF V_2 IS POSITIVE IT CONDUCTS AND CHARGES CAP C_2 (SOLID ARROWS). WHEN TUBE V_1 CONDUCTS IT CHARGES CAP C_1 (BROKEN ARROWS) THE POLARITY OF THE CAP. IS SUCH THAT THEY ADD UP. THE TOTAL LOAD VOLTAGE IS THE SUM OF BOTH CAP. VOLTAGES. THE CAP. CHARGE TO THE PEAK OF THE APLIED VOLTAGE. WHEN V_1 IS CONDUCTING CAP C_2 IS DISCHARGED THROUGH V_2 AND THE LOAD AND THE VOLTAGE ADDS TO THE INPUT PEAK VOLTAGE WHEN V_2 CONDUCTS CAP C_1 DISCHARGES THROUGH THE LOAD AND V_2 AND IT'S VOLTAGE ALSO ADDS TO THE INPUT. IF THERE IS NO LOAD WHEN THE CAP REACH THE PEAK VOLTAGE THE TUBES WILL CEASE TO CONDUCT. WHEN THE LOAD IS ON THE VOLTAGE WILL DROP FROM THE PEAK VOLTAGE.

THIS TYPE OF POWER SUPPLY CAN BE USED ONLY IN SYSTEMS WHICH REQUIRE LOW CURRENT. THIS IS KNOWN AS THE CONVENTIONAL DOUBLER

THE HALF WAVE OR CASCADE DOUBLER

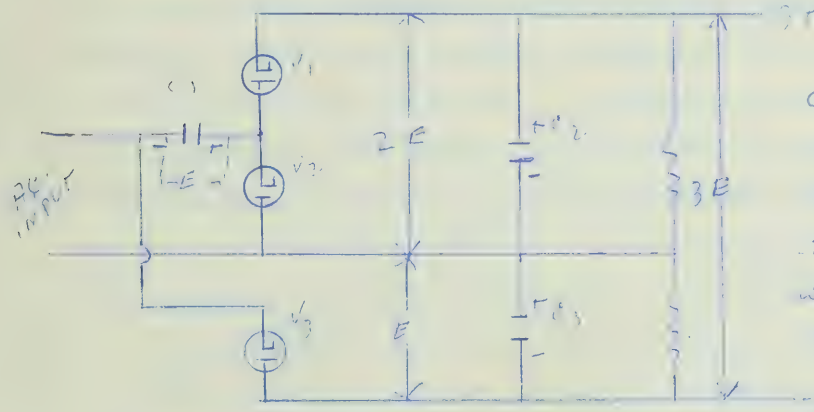




WHEN V_1 CONDUCTS (SECOND HALF CYCLE) C_2 IS CHARGED TO THE PEAK VOLTAGE. WHEN V_2 CONDUCTS THE VOLTAGE ACROSS THE CONDENSER IS ADDED TO THE SOURCE AND APPLIED TO C_2 TO APPROXIMATE DOUBLE THE PEAK INPUT VOLTAGE. C_2 DISCHARGE THROUGH THE LOAD WHEN V_2 IS CONDUCTING.

THIS TYPE IS ALSO FOR LOW CURRENT SYSTEMS POOR VOLTAGE REGULATION DUE TO THE VOLTAGE DROPAGE WHEN LOAD IS CONECTED.

THE CASCADE VOLTAGE DOUBLER CAN BE USED IN SERIES WITH HALF-WAVE RECTIFIER TO PROVIDE AN OUTPUT VOLTAGE WHICH IS EQUAL TO THREE TIMES THE PEAK VOLTAGE OF THE INPUT.



V_1 & V_2 WORK WITH C_1 & C_2 AS EXPLAINED ABOBE. V_3 PRODUCE ACROS C_3 A VOLTAGE EQUAL TO THE INPUT PEAK VOLTAGE WHICH ADDED TO THE PEAK VOLTAGE GIVES IN THE OUTPUT 3 TIMES THE PEAK

MERCURY VAPOR ARE USED IN POWER SUPLIES WHE HIGHER CURRENT IS NEEDED. THESE TUBES HAVE LESS INTERNAL RESISTANCE THAN REGULAR VA- CUM TUBES DUE TO IONIZATION. ALSO LESS PLATE "R"

TRIODE.

BY ADDING AN ELEMENT BETWEEN THE PLATE AND CATHODE THE TUBE BECOMES A TRIODE. THIS THIRD ELEMENT IS CALLED CONTROL GRID IT IS PLACED CLOSE TO THE CATHODE AND IT CONSISTS OF A SPIRAL WIRE O.R MESH.

TRIODE

THE PURPOSE OF THE CONTROL GRID IS TO CON-
TROL THE FLOW OF ELECTRONS IN THE TUBE, OR
THE EFFECT OF THE SPACE CHARGE.
IN THE DIODE IN ORDER TO HAVE A CHANGE
IN "Ip" THE "Ep" HAD TO BE CHANGE.
WITH THE CONTROL GRID A MUCH GREATER
CHANGE OF "Ip" CAN BE OBTAIN THAN WITH AN
"Ep" CHANGE. BY KEEPING THE "Ep" CONSTANT
THE TRIODE BECOMES MORE EFFECTIVE.
BY APPLYING A POSITIVE POTENTIAL TO THE GRID
THE FLOW OF ELECTRONS CAN BE ACCELERATED FROM
THE SPACE CHARGE TO THE PLATE.
AND BY APPLYING A NEGATIVE POTENTIAL THE
FLOW CAN BE COMPLETELY CUT OFF. THAT'S
HOW EFFECTIVE THE GRID CAN BE.

GREEK LETTER DELTA "Δ" MEANS CHANGE.

A SMALL "Δ" IN E_g CAN PRODUCE A GREAT Δ IN E_p
THAN A SMALL Δ IN E_c
NOMENCLATURE OF A TRIODE
"A" SUPPLY = FILAMENT SUPPLY E_f.
"B" " PLATE " (D.C) E_b
"C" " = GRID VOLTAGE (D.C) E_c.

IN A TRIODE THERE CAN BE A.C AND D.C COMPONENTS ON IT'S ELEMENTS.

∴

IN THE PLATE CKT. THE B+ SUPPLY TO THE CKT WILL BE KNOWN AS "E_{bb}" AND THE PLATE D.C VOLTAGE AS "E_b." THE D.C COMPONENT AS "I_b".

THE "RMS" VALUE OF THE A.C. VOLTAGE BY "E_p"

THE "RMS" " " " " " "I_p"

IN THE GRID CKT. THE D.C VOLTAGE BY "E_c"

" " " " " A.C " " "E_g"

THE INSTANTANEUS VALUES ~~OF~~ ~~BECOME~~.

FOR ~~THE PLATE CKT e_b~~, THE D.C COMPONENT

$e_b = E_b + e_p$. PLATE, e_b, i_b, FOR GRID e_c, i_c

$e_c = E_c + e_g$

AND FOR THE A.C COMPONENT.

PLATE. e_p, i_p. GRID e_g, i_p.

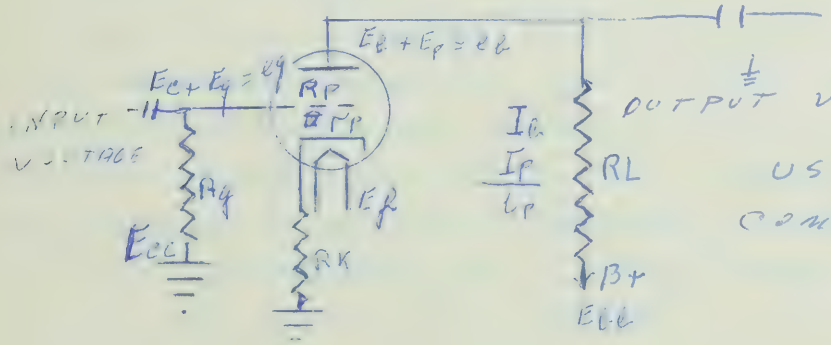
D.C PLATE RESISTANCE OF TUBE. R_P =

A.C " " " " r_p. =

CATHODE RESISTOR — " " R_K.

PLATE LOAD RESISTOR R_L.

GRID RESISTOR — R_g.



USING GROUND AS THE COMMON REFERENCE POINT.

TUBE CONSTANTS

STATIC CHARACTERISTICS CONDITIONS. (NO LOAD)

(1) D.C PLATE RESISTANCE $R_p = \frac{E_b}{I_b}$

(2) A.C. PLATE RESISTANCE $r_p = \frac{\Delta e_b}{\Delta i_b}$

(3) AMPLIFICATION FACTOR - $\mu = \frac{\Delta e_b}{\Delta e_g}$

(4.) TRANSCONDUCTANCE $G_m = \frac{\Delta i_b}{\Delta e_g} = (\text{mho})$

THE D.C PLATE RESISTANCE IS THE D.C INTERNAL RESIST. OF THE TUBE WHEN STEADY VALUES OF VOLTAGE ARE APPLIED.

THE A.C PLATE RESISTANCE IS THE A.C INTERNAL RESIST. OF A TUBE WHEN VARYING VALUES OF VOLTAGE ARE APPLIED. THE HIGHER THE PLATE VOLTAGE, (OR LOWER GRID VOLT.) THE LOWER THE r_p.

$\mu = G_m \times r_p$

AMPLIFICATION FACTOR IS THE RATIO BETWEEN A CHANGE IN PLATE VOLTAGE AND A CHANGE IN GRID VOLTAGE WHICH RESULTS IN THE SAME CHANGE IN PLATE CURRENT.

TRANSCONDUCTANCE OR MUTUAL CONDUCTANCE IS THE RATIO OF OF THE CHANGE IN PLATE CURRENT TO THE CHANGE IN GRID VOLTAGE WHICH PRODUCED IT, WITH PLATE VOLTAGE HELD CONSTANT AND IT IS MEASURED IN MHOS.

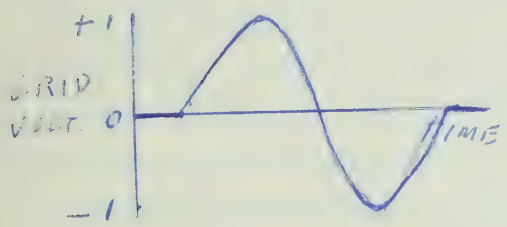
LOW	μ	LESS THAN 10
MEDIUM	μ	10 - 30
HIGH	μ	100 +

EFFECTS OF THE GRID

THE POTENTIAL ON THE GRID SETS UP AN ELECTROSTATIC FIELD WHICH IT EITHER HELPS OR PREVENTS THE FLOW OF ELECTRONS IN THE TUBE.

THE GRID IS USUALLY OPERATED AT A NEGATIVE POTENTIAL WITH RESPECT TO CATHODE. THIS POTENTIAL IS VARIED TO MORE OR LESS NEGATIVE. IF THE GRID WERE MADE POSIT. WITH RESPECT TO CATHODE, THERE WOULD BE AN INCREASE ON GRID CURRENT. (DESIRED IN MANY CASES.

CURVES SHOWIN RELATIONSHIP BETWEEN GRID VOLTAGE AND PLATE CURRENT (TRIODE)



IT CAN BE SEEN THAT 1 VOLT Δ IN THE GRID CAUSES 10 MA. Δ IN PLATE CURRENT AND THAT THE PLATE CURRENT IS IN PHASE WITH THE GRID VOLTAGE.

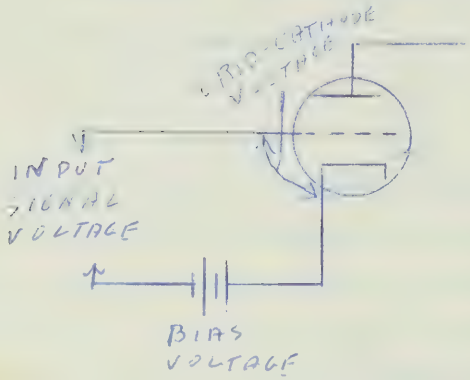
THE PLATE CURRENT DOES NOT CHANGE IN POLARITY. IT MERELY CHANGES IN VALUE FROM THE REFERENCE POINT. IT CAN BE DISCRIBED AS A DIRECT CURRENT WITH AN A.C. COMPONENT

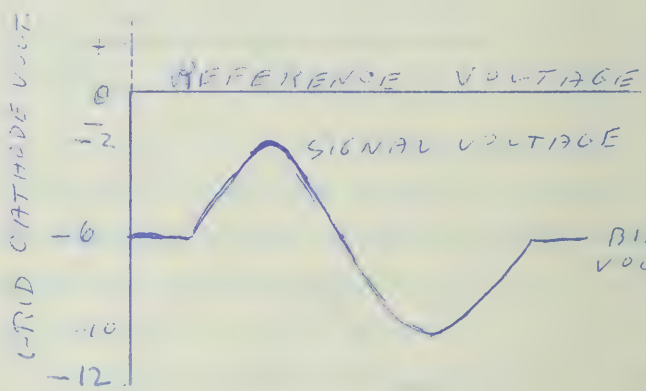
GRID BIAS MORE NEGATIVE. "Ib" ↓ "eb" ↑
" " " POSITIVE "Ib" ↑ "eb" ↓

BIAS VOLTAGE.

BIAS IS A D.C VOLTAGE BETWEEN THE GRID AND CATHODE. KEEPING THE GRID NEGATIVE

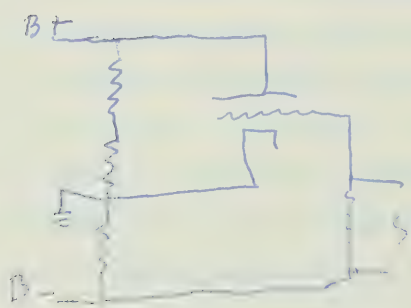
THE SIGNAL VOLTAGE ADDS TO THE BIAS VOLTAGE, THEREFORE IN ORDER TO KEEP THE GRID NEGATIVE, THE BIAS VOLTAGE MUST EQUAL OR EXCEED THE VALUE OF PEAK VOLTAGE OF THE SIGNAL.





TYPES OF BIAS.
FIXED BIAS AND SELF BIAS.

FIXED BIAS CAN BE FROM A BATTERY. ALSO IT MAY BE TAKEN FROM THE B+ POWER SUPPLY



METHOD OF POWER SUPPLY BIAS HAS THE DISADVANTAGE OF USING PART OF THE B+ SUPPLY.

SELF BIAS IS DEVELOPED BY THE RESISTOR IN THIS CATHODE CKT. THE PLATE CURRENT FLOWING THROUGH IT DEVELOPS THE BIAS VOLTAGE. THE CAP WILL KEEP THE VOLTAGE CONSTA

THE VALUE OF THE CATHODE CAPACITOR IS USUALLY 10 TIMES ONE ALTERNATION T.C. OF RESISTOR & CAPACITOR.

CHARACTERISTICS CURVES:

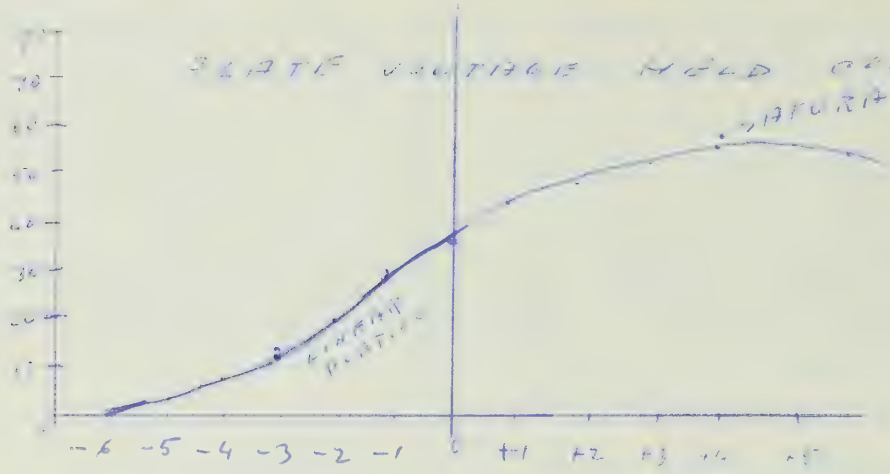
CHARACTERISTICS CURVES DISPLAY THE BEHAVIOR OF ELECTRON TUBES EASILY AND SPECIFICALLY.

NOTATIONS FOR CURVES:

"e_b" INST. TOTAL PLATE VOLTAGE
"E_b" AVER. TOTAL " "
"E_{bb}" B+ SUPPLY
"E_{bo}" - ZERO SIGNAL — AVER. TOTAL PLATE VOLT. (QUIESCENT)
"e_p" - INST. VALUE OF VARYING COMPONENT OF PLATE VOLT.
"e_1" INST. VALUE OF TOTAL VOLT. ACROSS RL.
"e_2" INST. A.C. COMPONENT. VOLT. ACROSS RL. (IMPEDANCE)
"E_{L0}" NO SIGNAL - D.C. VOLT ACROSS RL.
"E_{20}" VARYING COMP ACROSS RL. (IMPEDANCE)
"i_b" INST. TOTAL PLATE CURRENT
"I_b" AVER. " " "
"I_{bo}" ZERO SIGNAL, AVER. VALUE OF PLATE CURRENT
"i_p" INST. VALUE VARYING COMPONENT PLATE CURRENT
"e_c" INST. TOTAL GRID VOLTAGE
"E_c" AVERAGE TOTAL GRID VOLTAGE
"E_{cc}" GRID D.C SUPPLY
"e_g" INST. VALUE OF GRID [illegible]
"i_c" INST. TOTAL GRID CURRENT
"i_k" [illegible]
"E_K" AVER. " "
"i_k" INST. " " CURRENT
"I_k" AVERAGE D.C. CATHODE CURRENT

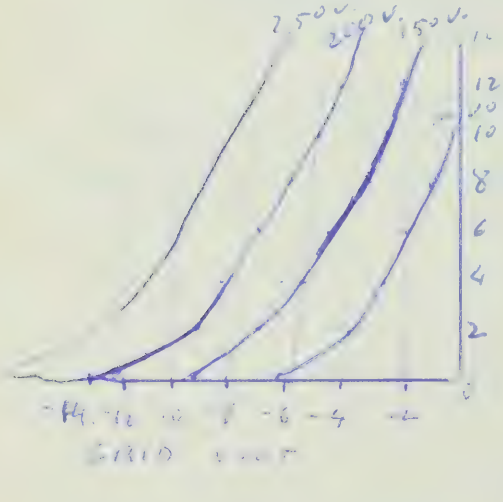
E_{bb} T $\rightarrow i_p$ ↓
NEGATIVE E_c ↑ $\rightarrow i_p$ ↓

STATIC PLATE CURRENT - GRID VOLTAGE CHARACT.



THIS CURVE SHOWS THAT AS THE GRID VOLTAGE IS MADE MORE POSITIVE THE Ib INCREASES UNTIL THE SATURATION POINT OF THE PLATE IS REACHED. INCREASING THE POSITIVE POTENTIAL ON THE GRID WILL NOT INCREASE THE Ib. IT WILL REDUCE IT DUE TO SECONDARY EMISION

FAMILY OF CURVES (STATIC TRANSFER)
GRID FAMILY AND PLATE FAMILY.



GRID FAMILY (STATIC CHARACTERISTICS CURVES.
CURVES SHOWS THE PLATE CURRENT INCREASE AS THE BIAS IS CHANGED AT A CONSTANT PLATE VOLTAGE
ALSO BY FOLLOWING THE GRID VOLTAGE UP IT CAN BE SEEN THAT THE PLATE CURRENT INCREASES AS THE PLATE VOLTAGE INCREASES.

IF THE PLATE CURRENT WAS TO BE HELD CONSTANT IT CAN BE SEEN THE AMOUNT OF GRID BIAS NEEDED TO OFFSET A CHANGE IN VOLTAGE AT THE PLATE. BY FOLLOWING THE PLATE CURRENT LINE TO THE LEFT AND OBSERVE WHERE IT CUTS THE PLATE VOLTAGE LINE AND GRID VOLTAGE LINE.

STATIC PLATE-CURRENT PLATE VOLTAGE CHARACTERISTICS.

PLATE FAMILY OF CURVES

GRID VOLTAGE IS HELD CONSTANT AND THE PLATE VOLTAGE IS VARIABLE.

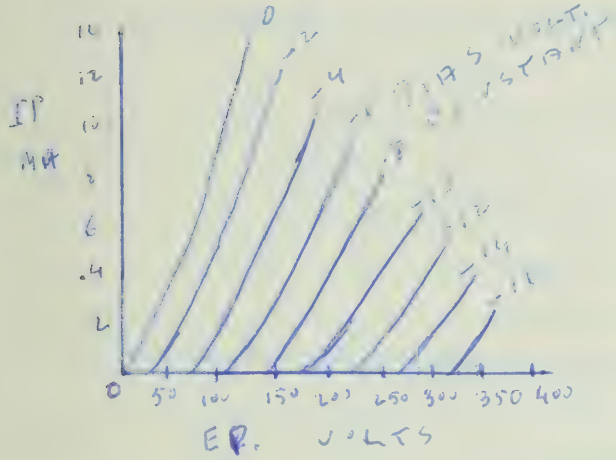


PLATE FAMILY.

ON EACH CURVE THE GRID VOLTAGE IS HELD CONSTANT AND THE PLATE VOLTAGE IS VARIED. IN THIS FAMILY LIKE IN THE GRID FAMILY THE EFFECTS ON ~~EA~~ PLATE CURRENT BY VARYING THE PLATE VOLTAGE CAN BE SEEN.

THE GRID FAMILY SHOWS THE PLATE CURRENT FOR SMALL INCREMENTS OF GRID VOLTAGE CHANGE AND SUBSTANTIAL FIXED DIFFERENCES IN PLATE VOLTAGE. THE PLATE FAMILY SHOWS THE EFFECTS OF SMALL INCREMENTS OF PLATE VOLTAGE AND LARGER FIXED INCREMENTS OF GRID VOLTAGE CHANGE.

THE BEHAVIOR OF THE PLATE CURRENT IN A TRIODE IS A FUNCTION OF THE DESIGN OF THE TUBE. THE FACTOR WHICH DETERMINE H.O. THE TUBE IS GOING TO OPERATE ARE CALLED "TUBE CONSTANTS" AND ARE GIVEN BY THE MANUFACTURER. THESE ARE UNDER STATIC CONDITIONS.

AMPLIFICATION FACTOR $\mu = \frac{\Delta E_p}{\Delta E_c}$ $\mu \uparrow$ $r_p \uparrow$

TRANSCONDUCTANCE $G_m = \frac{\Delta i_b}{\Delta e_c}$ $r_p \uparrow$ $G_m \downarrow$

A.C PLATE RESISTANCE ~~Rp~~ $r_p = \frac{\Delta e_b}{\Delta i_b}$

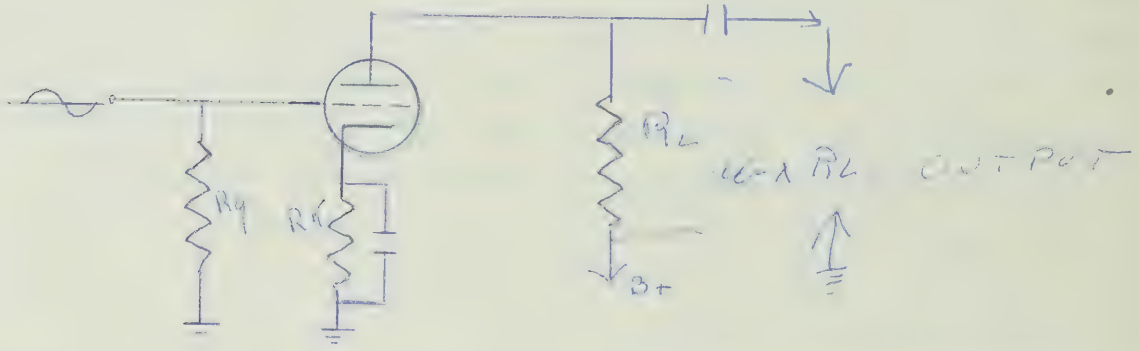
(D.C) $R_p = \frac{e_b}{i_b}$

RELATIONSHIP BETWEEN $r_p - G_m - \mu$.

$\mu = r_p \times G_m$ . . $r_p = \frac{\mu}{G_m}$. $G_m = \frac{\mu}{r_p}$

DYNAMIC CHARACTERISTICS OF A TRIODE

TUBE BEHAVIOR UNDER LOAD



THE AC. VOLTAGE PRESENT ACROSS THE GRID RES. IS THE INPUT VOLTAGE TO THE TUBE, VARYING THE GRID VOLTAGE. THIS VARIATIONS OF GRID VOLTAGES WILL CAUSE VARIATIONS OF PLATE CURRENT. THE CHANGE IN PLATE CURRENT WILL PRODUCE A CHANGE OF VOLTAGE ACROSS THE LOAD RESISTOR. THIS VARYING VOLTAGE IS THE OUTPUT OF THE TUBE. TAKEN BETWEEN THE THE RESISTOR AND GROUND OR ACROSS THE GRID RESISTOR OF THE NEXT STAGE.

THE VOLTAGES PRESENT IN THE PLATE CKT VARY WITH THE SIGNAL INPUT. IF THERE IS NO PLATE CURRENT FLOWING (TUBE CUTOFF) ALL THE B+ VOLTAGE WILL BE ON THE PLATE. (NO $i_b R_L$ DROP). AS THE CURRENT INCREASES TROUGH R_L THE $i_b R_L$ INCREASES UNTILL THEORICALLY ALL B+ IS ACROSS R_L. UNPOSSIBLE TO HAPPEN SINCE IF THERE IS NO POSITIVE POTENTIAL ON THE PLATE THE TUBE WILL HERSE CONDUCTION

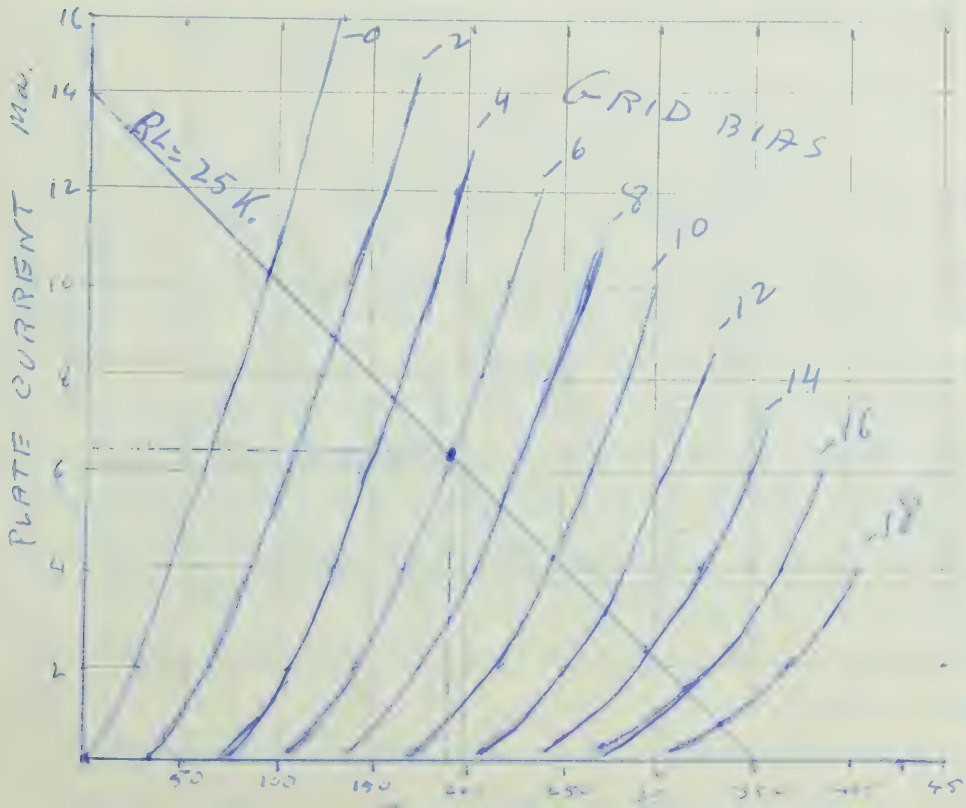
AT ANY TIME THE VOLTAGE DROPED ACROSS RL. AND THE VOLTAGE ON THE PLATE MUST EQUAL THE B+.

SINCE THE OUTPUT OF THE STAGE IS THE CHANGE OF VOLTAGE ACROSS RL, THE BIGGER THE CHANGE THE BIGGER THE OUTPUT. THERE FOR " THE HIGHER THE VALUE OF RL. THE HIGHER THE OUTPUT VOLTAGE. WILL BE" TO A CERTAIN POINT. THE PLATE MUST KEEP A POSITIVE POTENTIAL.

THE DYNAMIC CHARACTERISTICS DIFFER FROM THE STATIC CHARACTERISTICS IN THAT THE PLATE VOLTAGE IS NOT EQUALL TO THE B+.

DYNAMIC GRAPHS.
LOAD LINE.

THE PLATE FAMILLY OF CURVES IS USED TO SHOW THE LOAD LINE.



THE LOAD LINE CAN BE PICKED TWO WAYS. EITHER START WITH A VALUE OF LOAD AND A VALUE OF B+ OR A VALUE OF B+ AND PLATE CUR. THE EXTREMES OF THE LINE REPRESENT THE BOTH EXTREMES. ALL B+ ACROSS RL OR ALL B+ ON PLATE.

EACH CURVE REPRESENTS THE RISE OF PLATE CURRENT AS THE PLATE VOLTAGE IS INCREA WITH THE BIAS VOLTAGE KEPT CONSTANT.

THE POINT MARKED ON THE LOAD LINE REPRESENT A CURRENT FLOW OF 6.5 Ma AT 190 VOLTS ON THE PLATE WITH A BIAS OF −6 VOLTS WITH A LOAD OF 25 K.

THE CRL DROP CAN BE FINDED BY 6.5 X 25 K = 162.5 Volts.

WHEN A SIGNAL SOURCE AND LOAD AR USED THE FOLLOWING RELATIONSHIPS AR TRUE:

$ec = Ecc + ej$; $eb = Ebb - ibRL$.; $eRL = ibRL$.

DYNAMIC TRANSFER CHARACTERISTICS

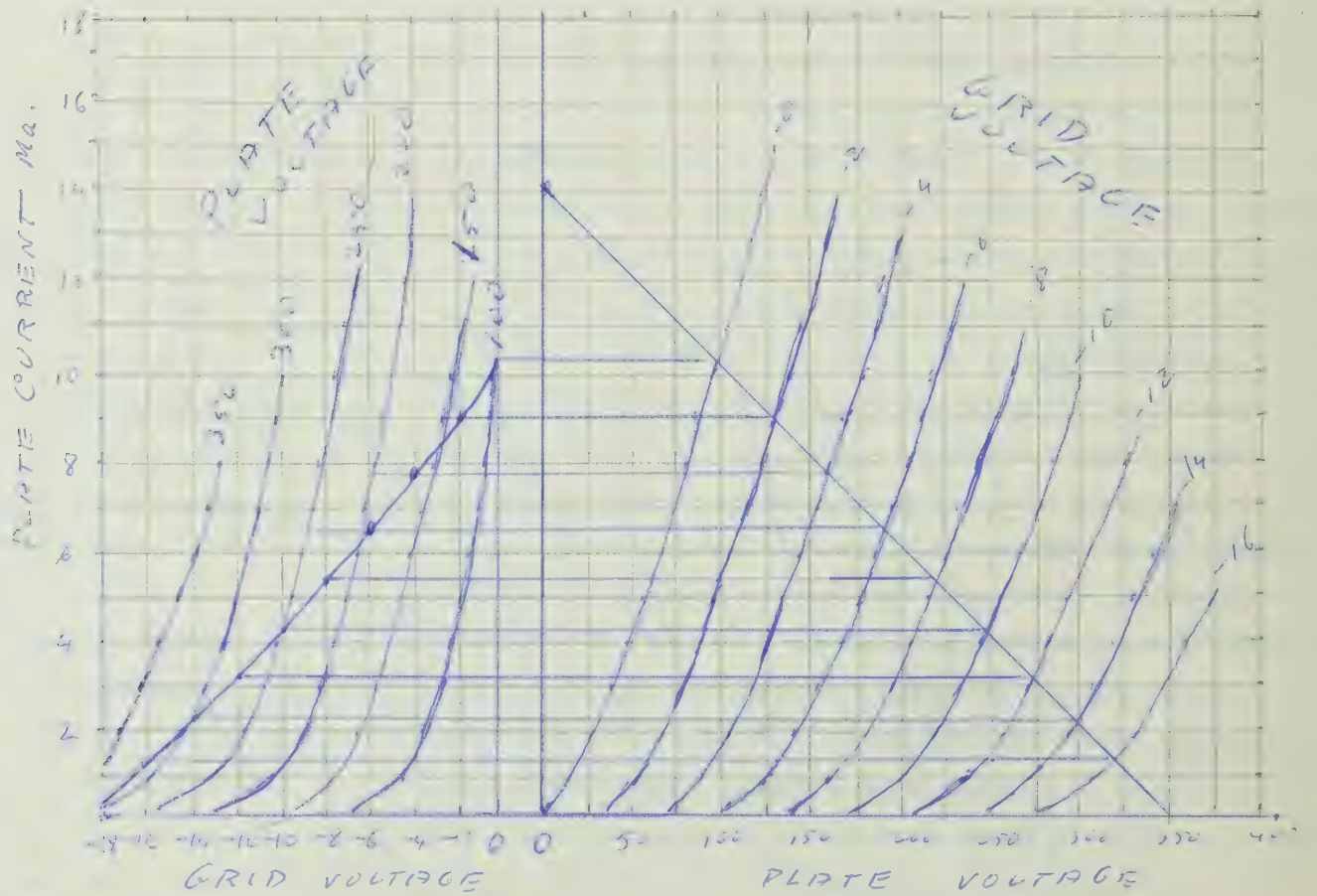


PLATE-CURRENT GRID VOLTAGE CURVE

PLATE VOLTAGE PLATE CURRENT CURVE

ON THE DYNAMIC CHARACTERISTICS THE EFFECT OF THE LOAD CAN BE NOTED. THE EFFECTS OF THE LOAD LINE ARE TRANSFERED TO THE PLATE CURRENT. GRID VOLTAGE

BY INPRESING THE CHANGE OF GRID VOLTAGE BY A SIGNAL ON THE LEFT SIDE, THE CHANGE IN CURRENT CAN BE FOUND IN THE OCLUM.

TRIODE AMPLIFIERS

THE SIGNAL VOLTAGE INPUT TO A TRIODE ADDS UP TO THE BIAS VOLTAGE. IF THE BIAS IS −6 VOLTS AND THE SIGNAL VOLT. IS 6 VOLT PEAK TO PEAK THE Eg. IS GOING TO BE −12 AND 0 VOLTS IN THE GRID. THE CHANGE OF CURRENT IN THE LOAD WILL PRODUCE A VOLTAGE WHICH WILL BE THE OUTPUT VOLTAGE.

THE TOTAL CHANGE IN PLATE VOLTAGE ALWAYS IS EQUAL TO THE CHANGE IN VOLTAGE ACROSS THE LOAD.

THE DYNAMIC TRANSFER CHARACTERISTICS IS SUFFICIENT FOR GRAPHICAL DISPLAY OF THE WAY IN WHICH A SIGNAL VOLTAGE APPLIED TO THE GRID REAPPEARS AMPLIFIED IN THE PLATE CKT. VIA THE PLATE CURRENT.

OPERATING POINT-
QUIESCENT CONDITIONS: NO SIGNAL APPLIED, NO OUTPUT CHANGE.
LINEAR PORTION OF THE PTATE CURRENT GRID VOLTAGE CURVE

INTERELECTRODE CAPACITANCE.

CAPACITANCE BETWEEN ELEMENTS OF TUBE

C_{gk} - GRID TO CATHODE CAP.

C_{gp} - GRID TO PLATE CAP.

FROM 2 TO 10 $\mu\mu$fd.

CAUSE FEEDBACK AND OSCILLATIONS.

APPROXIMATE VALUES:

R_L - UP TO 10 TIMES r_p.

R_K 100 TO 3000 Ω

R_g $\frac{1}{2}$ MEG UP

C_c - .002 TO .05 μfd.

C_K - 10 TIME R.C. OF ONE ALTER. OF AMP-FR.

AMPLIFICATION.

VOLTAGE AND POWER AMPL.

MOST IMPORTANT USE OF A TUBE IS TO AMPLIFY

THE AMOUNT OF AMPLIFICATION OBTAIN IN A AMPLIFIER STAGE IS CALLED "GAIN"

GAIN IS THE RATIO OF OUTPUT TO INPUT

$$\text{GAIN} = \frac{\text{OUTPUT}}{\text{INPUT}}$$

AUDIO, R.F, POWER AMPL.

AMPLIFIER DISTORTION DEPENDS ON THE LINEARITY OF ITS CHARACTERISTICS. THE MORE LINEAR THE LESS THE DISTORTION.

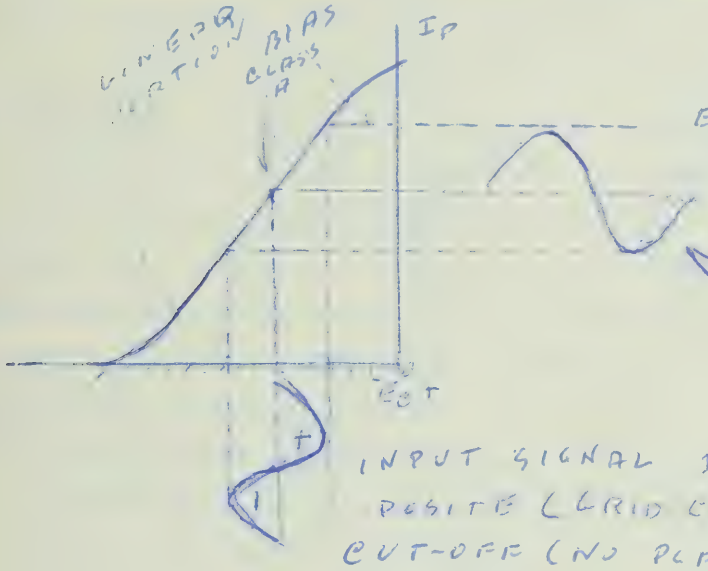
PROPER SELECTION OF OPERATING POINT WILL HELP TO MINIMIZE DISTORTION.

CLASSES OF OPERATION

A - AB - B - C.

CLASS A AMPLIFIERS.

THEY ARE BIASED SO PLATE CURRENT FLOWS CONSTANTLY OR 360° OF SIGNAL



OUTPUT SIGNAL UNDISTORTED EXACT REPRODUCTION OF INPUT SIGNAL BUT AMPLIFIED

PLATE CURRENT

INPUT SIGNAL DOES NOT DRIVE THE GRID POSITIVE (GRID CURRENT FLOW) OR BEYOND CUT-OFF (NO PLATE CURRENT)

CLASS B AMPL.

THEY ARE BIASED NEAR OR AT CUT-OFF PLATE CURRENT FLOWS 180° (POSITIVE SIDE).

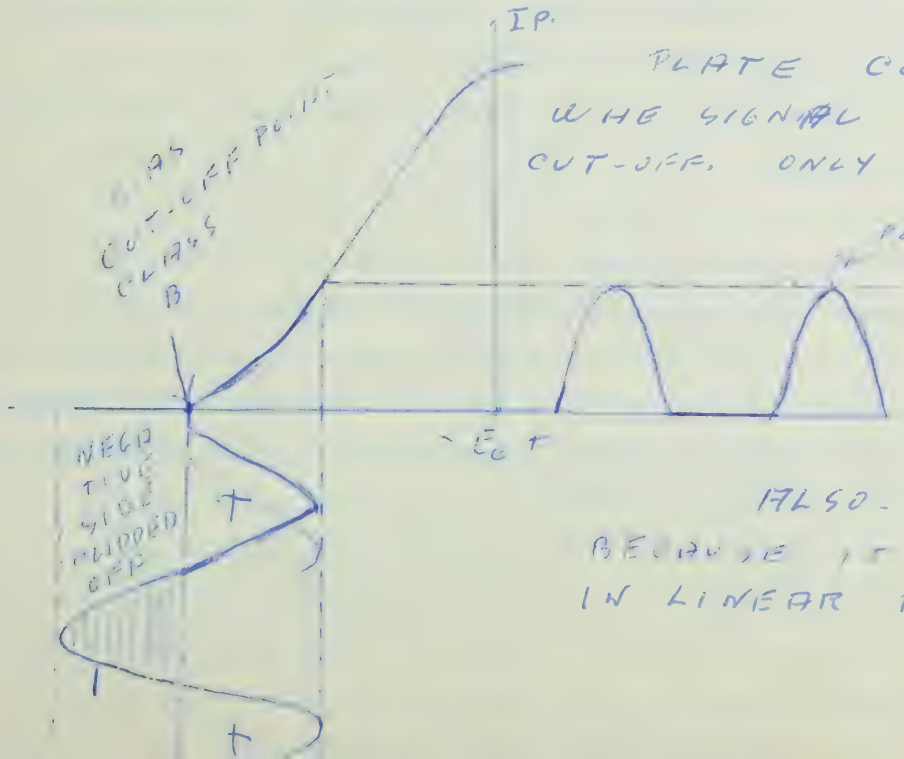


PLATE CURRENT STARTS WHEN SIGNAL DRIVES GRID OVER CUT-OFF. ONLY ON POSITIVE SIDE

PLATE CURRENT

DISTORTED OUTPUT WAVE - NO NEGATIVE SIDE

ALSO. WAVE DISTORTED BECAUSE IT IS NOT BIASED IN LINEAR PORTION.

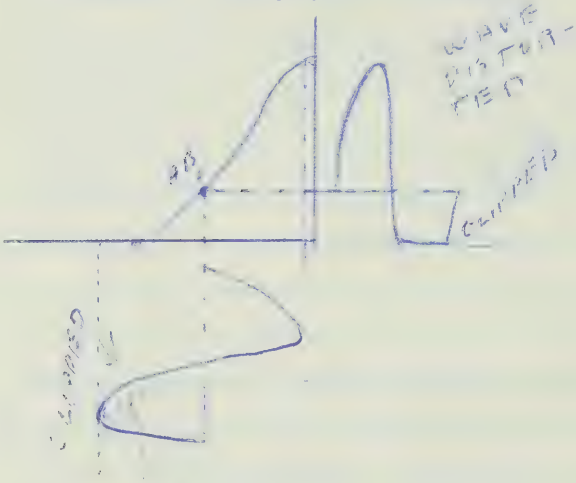
CLASS AB AMPL. BIASED BETWEEN "A" & "B"

"AB_1" & "AB_2".

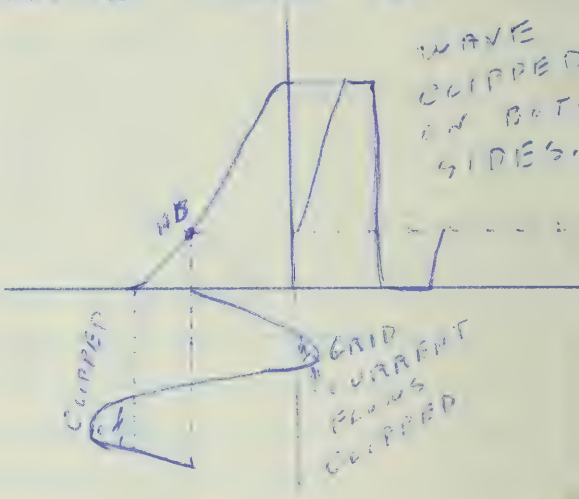
AB_1 NO GRID CURRENT FLOW

AB_2 GRID GOES POSITIVE AND GRID CURRENT FLOWS.

PLATE CURRENT FLOWS MORE THAN 180° BUT LESS THAN 360°



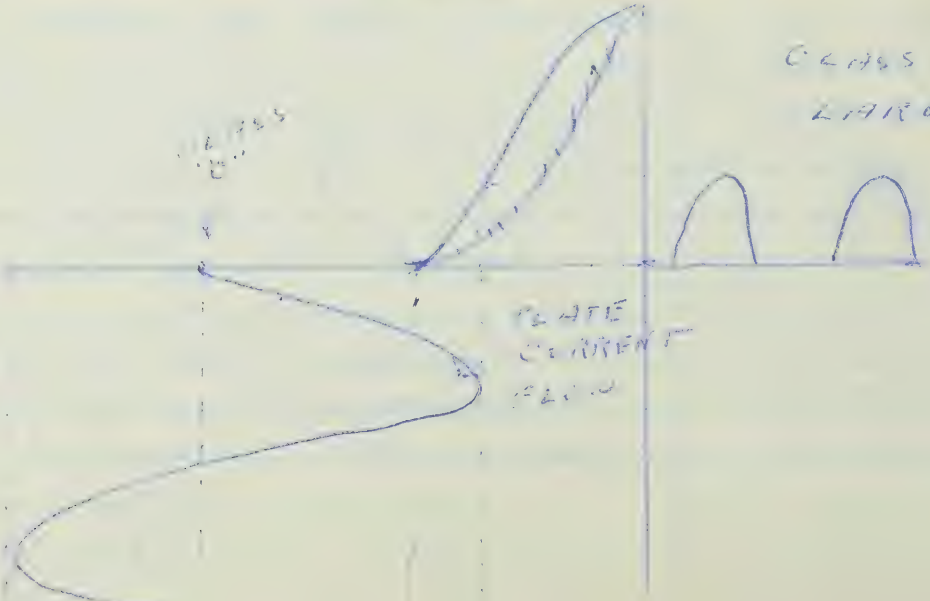
"AB_1"



CLASS "AB" PRODUCES MORE DISTORTION THAN CLASS "A" BUT MORE POWER OUTPUT AND GREATER PLATE EFFICIENCY

CLASS "C" AMPLIFIER BIASED BETWEEN 1½ TO 4 TIMES CUT-OFF POINT.

CURRENT FLOWS 90° OR LESS ON POSITIVE PEAK



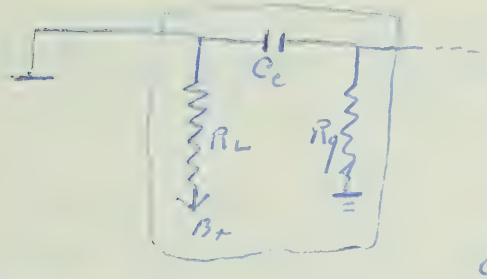
CLASS "C" NEEDS A LARGE SIGNAL.
GREATER DISTORTION
GREATER EFFICIENCY.

VOLTAGE AMPL. - GAIN AND COUPLING

R.C COUPLED.

VOLTAGE AMPL. PRODUCE A LARGE VOLTAGE AND SMALL CURRENT AT ITS OUTPUT.
THE RL IN VOLT. AMPL. IS LARGE IN VALUE

R. C. COUPLING NETWORK.



RL - C_c - R_g

THE VARYING A.C VOLTAGE FROM THE TUBE ACROSS RL. CHARGES AND DISCHARGES THE C_c. WHICH IN CONJUCTION WITH R_g FORM A VOLTAGE DIVIDER. THE A.C. VOLTAGE DEVELOPED ACROSS R_g IS THE SIGNAL INPUT VOLTAGE TO THE TUBE.

THE VALUE OF R_L SHOULD BE AS LARGE AS POSIBLE, SO AS TO DEVELOPE A CHARGE VOLT

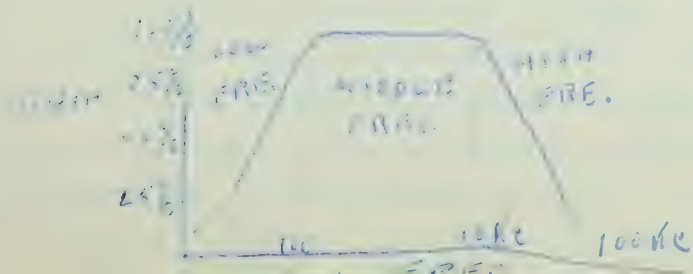
THE VALUE OF C_c (ALSO CALLED D.C BLOCKING CAPC.) SHOULD BE FAIRLY LARGE SO THE REACTANCE CAN BE SMALL

THE VALUE OF R_g IS VERY LARGE.

SINCE THE REACTANCE OF THE C_c IS VERY SMALL TO THE SIGNAL VOLT. IT APEARS MAINLY ACROSS THE R_g.

GAIN OF THE R C. COUPLE AMPL.

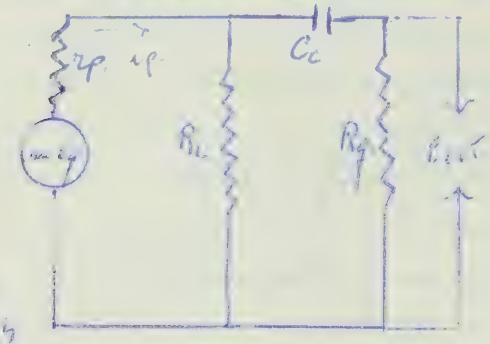
AMPL. ARE RATED FOR THEIR GAIN.
GAIN VARIES AT DIFFERENT FREQ.
RES PONSE CHARACTERISTICS CURVE. FREQ PLOTED AGAINST RELATIVE GAIN



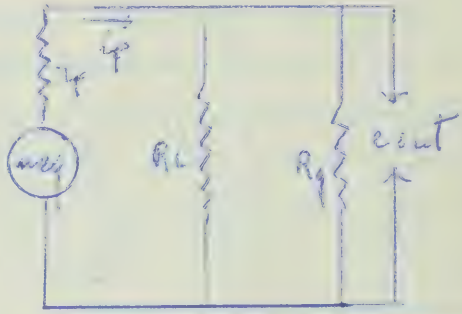
THE C_c IS HAS THE MINIMUM REACTANCE TO THE MIDDLE FREQ.

AT THE LOW FREQ. THE REACTANCE OF C_c INCREASES DROPING MORE SIGNAL

SIGNAL ACROSS IT - DECREASING THE GAIN
THE RESPONSE AT THE HIGH FREQ. DROPS BECAUSE
OF THE LOW REACTANCE PRESENTED BY THE
INTERELECTRODE, STRAY AND WIRING CAPS.
TO GROUND THEREFORE, SHORTING THE SIGN
T- GROUND AND DECREASING THE GAIN.

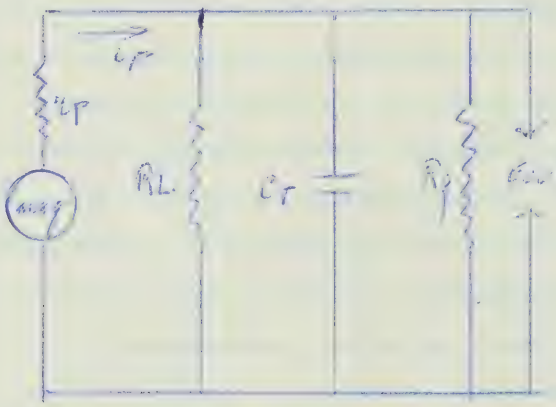


LOW FR. EQUIVALENT CKT.



MIDDLE FR. EQUIVALEN
CKT

BV
IN HIGH FR.
DECREASES



HIGH FR. EQUIVALENT
CKT.

THIS EQUIVALENT CKT
REPRESENT THE AMPL
STAGE AT DIFFERENT
FR.
THE OUTPUT SIGNAL O
THE AMPL. IS REPRE
SENTED AS "Avg" WH
MEANS, THE AMPL. SUPP
FICTION FACT - IT TAKE
THE INPUT SIGNAL VOLT.
THESE ARE A.C EQUIVALENT CKTS SO THE D.C
VOLTAGES ARE NOT SHOWN

WE MAY CONSIDER THE VOLTAGE AMPL OF TH
STAGE AS THE RATIO OF THE OUTPUT VOLTAG
TO THE INPUT SIGNAL VOLTAGE. OR

$$A_v = \text{VOLTAGE GAIN} = \frac{e_{out}}{e_g}$$

ON THE THREE EQUIVALENT CKTS IT CAN BE
SEEN THE FR. RESPONSE AT THE LOW FR.
OF e_g THE HIGHER THE VOLTAGE ACROSS C_c AND
THE LOWER THE DROP ACROSS R_g.

IN THE MIDDLE FR. RANGE THE REACTANCE OF C_C IS NEGLIGIBLE SO IT IS OMITED.
AT THE HIGH FRE. THE CAP. Ct REPRESENT THE TOTAL CAP. (INTERELECTRODE, STRAY. ETC.) TO GROUND AS THE SIGNAL FR. INCREASES THE REACTANCE DECREASES AND MORE OF THE SIGNAL IS BY-PASSED OR SHORTED TO GROUND.

TRIODE AMPL. GAIN
MATHEMATICAL RELATIONSHIPS.
VALUES ON EQUIVALENT CKTS.

e_{eq} = OUTPUT VOLT; r_p - A.C. PLATE RESISTANCE
R_L = LOAD RESISTOR - i_p = PLATE CURRENT
e_{out} - SIGNAL OUTPUT VOLTAGE
A_v = VOLTAGE AMPLIFICATION.

$$A_v = \frac{e_{out}}{e_g} = \frac{e_{out}}{e_g}$$

OHMS LAW; $i_p = \frac{e_{eq}}{r_p - R_L}$ (Series Ckt)

e_{out} ACROSS R_L = $i_p \times R_L$

SUBSTITUTING FOR i_p: $e_{out} = \frac{e_{eq}}{r_p + R_L} \times R_L = \frac{e_{eq} R_L}{r_p + R_L}$

STATED $A_v = \frac{e_{out}}{e_g}$

SUBSTITUTING e_{out}: $A_v = \frac{\frac{e_{eq} R_L}{R_L + r_p}}{e_g}$

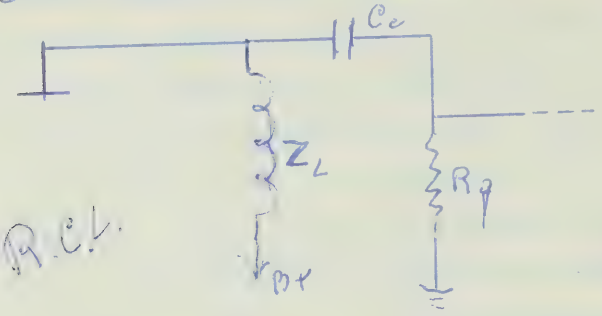
CANCELING BOTH e_g $A_v = \frac{\mu R_L}{R_L + r_p}$

THESE EQUATIONS SHOW AND PROVE THE VOLTAGE GAIN OR AMPLIF. OF AN AMPL.

THEY SHOW THAT IF THE RL IS INCREASED IT WILL INCREASE THE AV.

IMPEDANCE COUPLING (R.C.L).

IF A COIL IS SUBSTITUTED FOR RL AN R.C.L COUPLING NETWORK RESULTS (IMPEDANCE COUPLIN

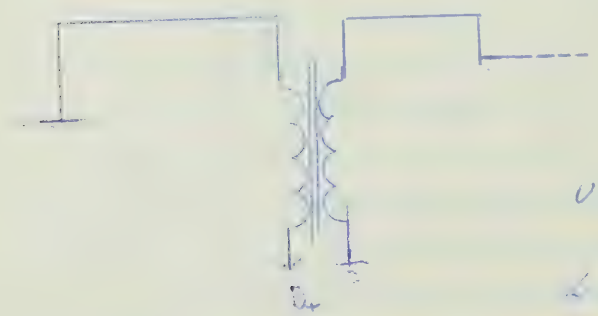


THE A.C IMPEDANCE OF THE COIL IS VERY HIGH TO THE SIGNAL AN A LOW D.C RESIST. TO THE PLATE VOLTAGE THEREFORE A LOWER D.C SUPPLY CAN BE USED, AN THE PLATE CURRENT IS HIGHER.

POOR FR. RESPONSE. BECAUSE THE IMPEDANCE OF THE COIL VARIES WITH THE FR. AT LOW FR. THE IMPED. DROPS SO THE GAIN ALSO DROPS ON THE HIGH FR. THE CAP. OF THE WIRING OF THE COIL SHORTS OUT MUCH OF THE SIGNAL.

FR. ↓ ZL ↓ LESS SIGNAL
MIDDLE FR ZL ↑ MORE "
FR. ↑ Xc ↓ SHORTS OUT SIGNAL.
NOT USED ON AUDIO AMP.

X FORMER COUPLING.



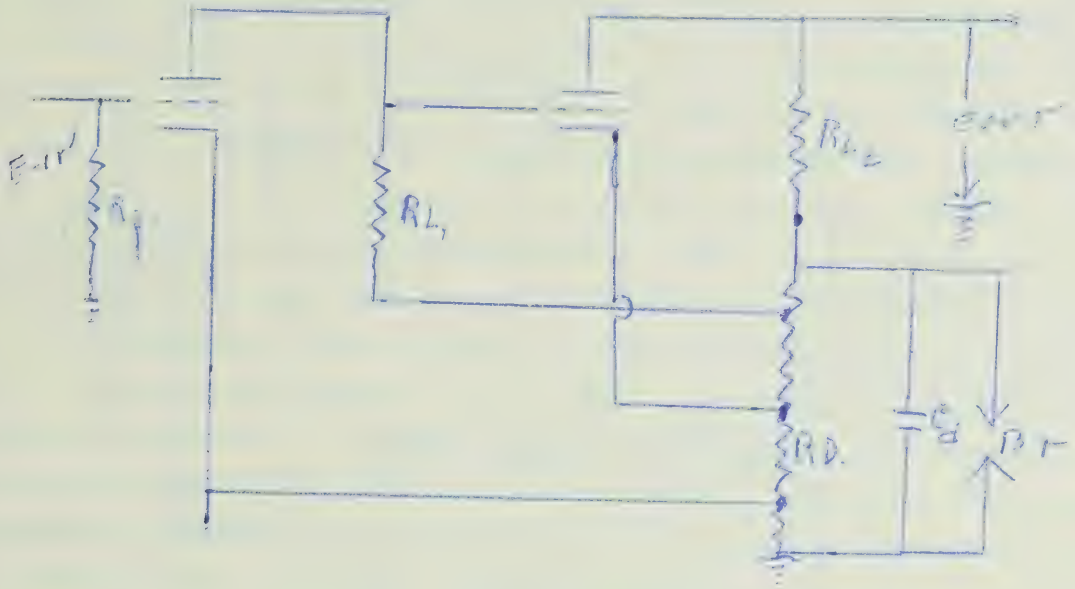
COUPLING BY X FORMER IS TION.
HIGH GAIN DUE TO STEP UP X FORMER.

LIMITATION IS POOR FR. RESPONSE LIKE IN IMPEDANCE.
NO GOOD AT VHF BECAUSE THE DISTRIBUTED CAPACITANCE OF THE WINDING

MORE ABOUT X FORMERS LATER IN NOTES

DIRECT COUPLE AMPL.

OUTPUT COUPLED DIRECTLY.



THE R_2 VOLTAGE DIVIDER IS USED TO MAINTAIN THE POSITIVE POINTS.

NO LOSS OF SIGNAL - NO REACTIVE ELEMENTS ALSO FAIRLY UNIFORM FR. RESPONSE. BETTER AT LOW FR. - GOOD FOR LARGE CURRENT.

DISADVANTAGE: TOO BIG POWER SUPPLY.

CLASSIFICATION OF AMPL.

1. MODE (CLASS)
2. COUPLING.
3. VOLTAGE OR POWER
4. FREQUENCY.

TROUBLE SHOOTING HINTS:

DISTURB GRID OF LAST STAGE. CHECK B+

LEAKY C_c. - VTVM WOULD SHOW POSITIVE FROM GRID TO GROUND

HUM: B+

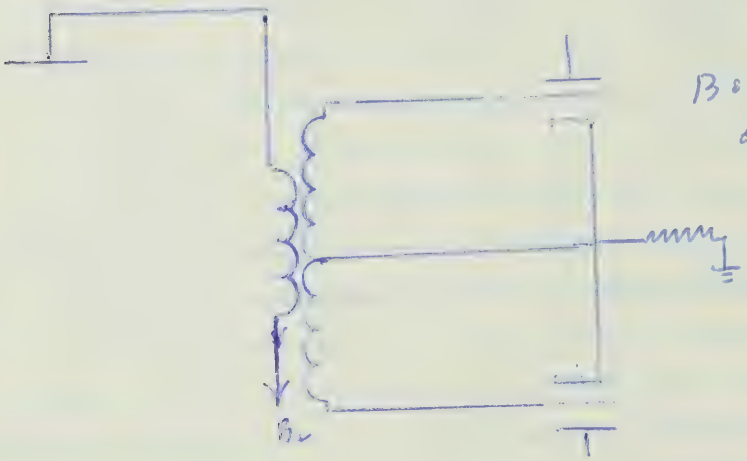
60 CYCLE - FILAMENT

120 " B+.

PHASE INVERSION IN AMPLIFIERS

NEEDED FOR PUSH-PULL AMPL. TWO GRIDS MUST BE 180° OUT OF PHASE.

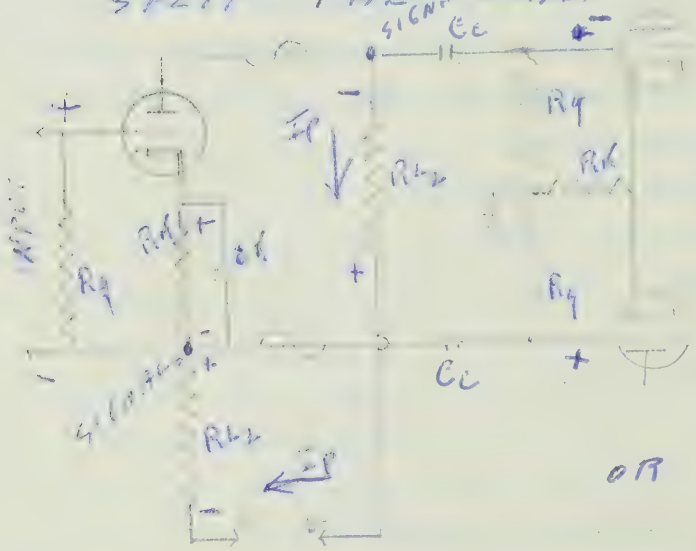
CAN BE DONE SINGLE-ENDED WITH XFORMER WITH SECONDARY CENTERTAPPED.



BOTH GRIDS ARE 180° OUT OF PHASE.

XFORMER IS TOO EXPENSIVE.
POOR FIDELITY

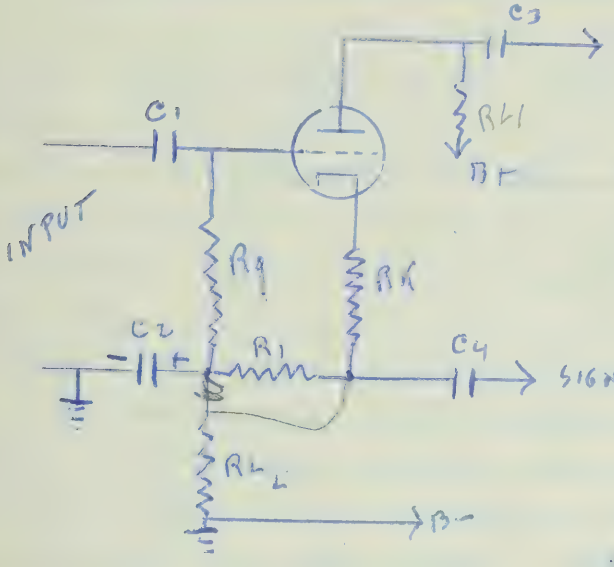
WITH R.C. COUPLING. ONE METHOD IS TO SPLIT THE SIGNAL LOAD.



THE VALUES OF R_{L_1} & R_{L_2} MUST BE EQUAL SO THE PLATE CURRENT WILL DEVELOPE THE SAME VOLTAGE ACROSS THEM. THE POLARITY IS OPOSITE AT THE POINTS WHERE THE SIGNALS ARE TAKEN FOR THE PUSH-PULL TUBE OR 180° OUT OF PHASE.

A DISADVANTAGE OF THIS CKT IS THAT THE LOW END OF THE INPUT IS NOT GROUNDED. IT IS LEFT FLOATING ABOVE GROUND. THIS WILL CAUSE A LOT OF HUM BEING PICKED UP. CAN'T BE FED FROM GROUNDED SOURCE

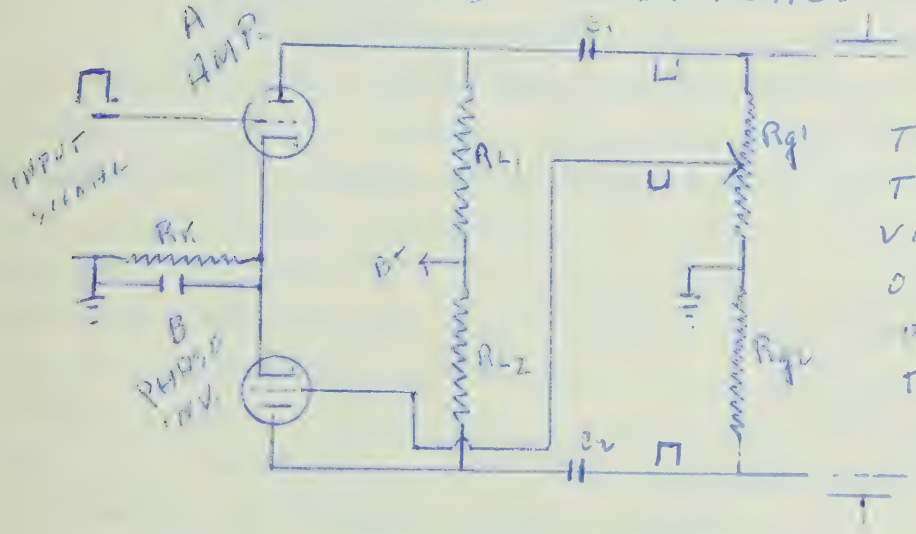
A MODIFICATION OF THE PREVIOUS CKT.



THIS CKT PERMITS A GROUNDED INPUT. C_1 IS AN ORDINARY COUPLING CAP. BUT C_2 MUST BE LARGE - (5 MFD.) AND IT MAY BE AND ELECTROL R_1 & R_{L2} ARE IN PARALL AS FAR AS THE SIGNAL IS CONCERN SO BOTH MUST EQUAL TO R_{L1} SO THE AMPLITUDE OF BOTH OUT- PUT SIGNALS MAY BE EQUAL

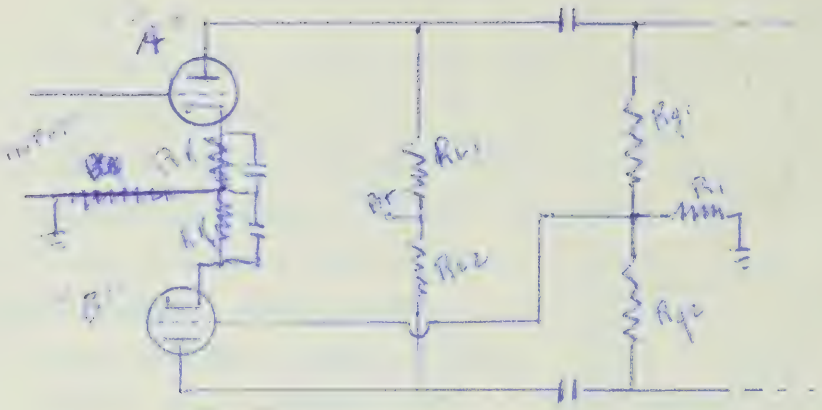
ALSO R_K IS NOT BY PASSED. IT'S VALUE IS TOO SMALL COMPARED TO THE REMAINDER OF THE RESISTANCE IN THE PLATE CKT.

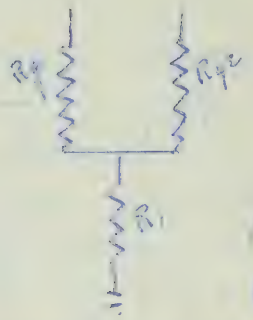
PARAPHASE INVERTERS.



WHEN THE GRID OF TUBE "A" GOES POSITIVE THE PLATE GOES NEGATIVE AND THE GRID VOLTAGE OF TUBE "B" BEING TAPPED FROM "R_{g1}" IS NEGATIVE. THEREFORE THE OUTPUT OF BOTH TUBES IS 180° OUT OF PHASE. THE AMOUNT OF SIGNAL VOLTAGE FED TO TUBE "B" MUST BE EQUAL TO THE INPUT OF TUBE "A" SO THE AMPLITUDE OF BOTH OUTPUTS WILL BE EQUAL. R_{L1} & R_{L2} MUST BE EQUAL.

A SELF-BALANCING CKT PHRAPHASE INVERTER ARRANGES ITSELF WITHOUT A PART OF THE CKT





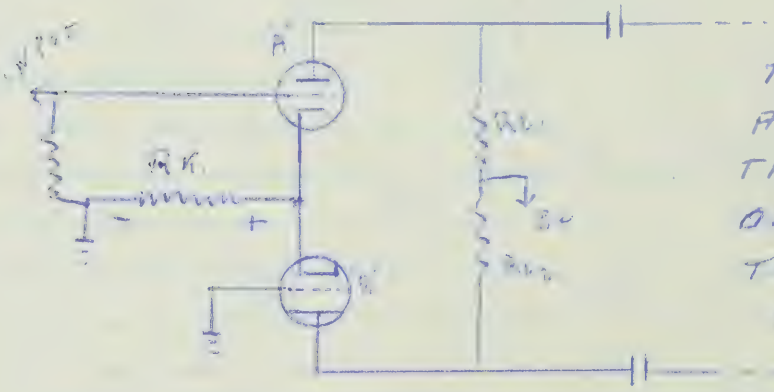
EQUIVALENT CKT OF THE VOLTAGE DIVIDER

Rg1, Rg2 & R1 - SAME VALUE.

THE OUTPUT OF BOTH TUBES ARE FROM ACROSS R1 BUT THEY ARE 180° OUT OF PHASE, SO THEY TRY TO CANCEL EACH OTHER. THE VOLTAGE DROPED ACROSS R1 IS FED TO THE GRID OF TUBE "A". THIS VOLTAGE ~~HAVE~~ MUST EQUAL THE INPUT OF TUBE "A" AND IT* EQUALS THE DIFFERENCE OF BOTH OUTPUTS. IF THE SIGNAL VARIES IN TUBE "A" THE VOLTAGE IN R1 WILL ALSO VARY AND CHANGE THE GRID VOLTAGE OF TUBE "B" THEREBY EQUALIZING THE OUTPUTS.

ONE TUBE - TWO TRIODE MAY BE USED.

CATHODE COUPLE OR GROUND GRID PHASE INVERTER.



TUBE "A" AMPLIFIES TUBE "B" PHASE INVERT.

THE VOLTAGE THAT APEARS ACROSS RK IS THE SIGNAL VOLTAGE OF TUBE "B". THIS BEING THE ALGEBRAIC SUM OF THE TWO PLATE CURRENTS. IT HAS THE SAME ~~SHAPE~~ SHAPE THAT THE INPUT OF TUBE "A" BUT 180° OUT OF PHASE. IT IS $\frac{1}{2}$ OF VALUE OF ONE ALTERNATION OF SIGNAL OF FIRST TUBE

DEGENERATION OCCURS.

CATHODE COUPLE FOR LOW IMPEDANCE

GROUND GRID LOW IMPEDANCE

REF:

RADAR BOOK

TETRODES

POWER AMPLIFIERS.

DISADVANTAGE OF TRIODES - INTERELECTRODE CAP.

SCREEN INTRODUCES AN ELECTROSTATIC FIELD WHICH ELIMINATES A GREAT PART OF THIS CAP. MUST BE AT SIGNAL GROUND TROUGH A CAPACITOR.

HELPS ATRACT ELECTRONS FROM THE SPACE CHARGE TO THE PLATE

MAKES "IP" INDEPENDENT FROM CHANGES OF "EP" BECAUSE OF IT'S POSITIVE POTENTIAL.

CONTROLS THE SPACE CHARGE.

CONSTANTS OF TUBES CHANGE

$\mu = \frac{\Delta EP}{\Delta E_g}$ THE "MU" OF THE TUBE IS GREATLY INCREASED BECAUSE THE RATIO OF EP TO E_g (CHANGE) IT'S INCREASE. SINCE A MUCH GREATER CHANGE IN "EP" IS NEEDED TO PRODUCE THE SAMA CHANGE ON "IP" THAN A SMALL CHANGE IN "E_g" THEREFORE THE CONTROL GRID HAS A MUCH GREATER CONTROL ON "IP" (μ OVER 500)

IT FOLLOWS THAT THE "r_p" IS ALSO GREATLY INCREASED SINCE "r_p" $= \frac{\Delta EP}{\Delta IP}$; A GREATER CHANGE IS NEEDED ON "EP" TO PRODUCE A SMALL CHANGE IN "IP" (OVER 100K)

THE "G_m" IS FAIRLY CONSTANT $G_m = \frac{\mu}{r_p}$

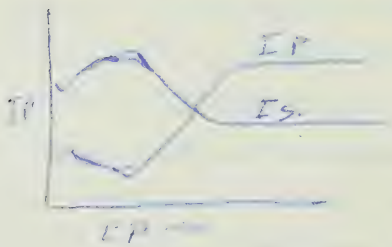
BOTH FACTORS INCREASE (ALSO $G_m = \frac{\Delta IP}{\Delta E_g}$)

IT MAY BE LOWER THAN TRIODES

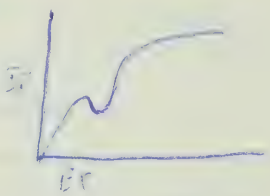
ANOTHER EFFECT INTRODUCED BY THE SCREEN IS THE "NEGATIVE RESISTANCE" CAUSED BY SECONDARY EMISSION.

THIS IS AN EFFECT OF THE + POTETEN-
TIAL ON THE SCREEN.

IF THE PLATE VOLTAGE GOES LOWER THAN THE SCREEN'S THE EFFECTS OF SECONDARY EMISSION ARE INCREASED BECAUSE THE SECONDARY ELECTRONS ARE ATTRACTED BY THE SCREEN INSTEAD OF BY THE PLATE CAUSING AN ELECTRON FLOW IN OPPOSITION TO THE NORMAL FLOW THEREFORE DECREASING THE "EP" AND INCREASING THE SCREEN CURRENT. THE AREA OF NEGATIVE RESISTANCE IS AT THE POINT WHERE THE PLATE VOLT. IS EQUAL OR LOWER THAN THE SCREEN.

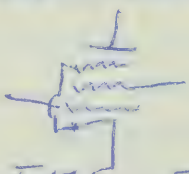


THE PLATE CURRENT DECREASES AS THE PLATE VOLTAGE INCREASES.



THE DISADVANTAGES OF THE TETRODE ARE THE NEED FOR HIGH PLATE VOLTAGE SUPPLY, SO IT CAN BE OPERATED ABOVE THE SCREEN. ALSO THE LIMITED SIGNAL VOLTAGE TO PREVENT LARGE SWINGS OF THE PLATE VOLTAGE.

PENTODES:



SUPRESOR GRID ADDED TO THE TETRODE TO ELIMINATE THE EFFECT OF SECONDARY EMISSION CONNECTED TO CATHODE. NEGATIVE REPELS BACK TO THE PLATE THE ELECTRONS.

THE "r_p" OF A PENTODE IS HIGH ABOUT 1.5 MΩ

THE "g_m" IS ALSO HIGH - 1500

THE "G_m" IS AVERAGE.

THE SUPRESOR GRID MAKES POSIBLE GREATER POWER OUTPUT WITH LOWER GRID VOLTAGE ALSO LARGE VOLTAGE SWING. BY THE FACT THAT THE "EP" SWING CAN BE MADE LARGE

4 IF THE VOLTAGE ACROSS ANY BRANCH IS NOT KNOWN ASUME A VOLTAGE

5 DIVIDE THE VOLTAGE OF (4) BY THE VECTOR IMPEDANCE OF EACH PARALELL BRANCH (POLAR FORM). THE QUOTIENT IS THE VECTOR CURRENT THROUGH THE BRANCH AND IT HAS THE SAME ANGLE BUT OF OPPOSITE SIGN TO THE RESPECTIVE IMPEDANCE

6 RESOLVE THE CURRENTS THROUGH THE PARALELL BRANCHES INTO THEIR RECTANGULAR COMPONENTS AND ADD THEM. THIS SUM REPRESENTS THE RECTANGULAR COMPONENTS OF THE TOTAL CURRENT THROUGH THE PARALELL COMBINATION.

7 FIND THE VECTOR CURRENT (POLAR FORM) OF THE TOTAL CURRENT FOUND IN (6).

8 DIVIDE THE VOLTAGE OF (4) BY THE VECTOR CURRENT FOUND IN (7). THE QUOTIENT IS THE JOINT VECTOR IMPEDANCE OF THE PARALELL CKT AND HAS AN ANGLE EQUAL AND OPPOSITE TO THE TOTAL CURRENT FOUND IN (7)

9 SOLVE FOR THE JOINT IMPEDANCE FOUND IN (8) INTO AN EQUIVALENT SERIES CKT (RECTANGULAR FORM)

10 THE EQUIVALENT SERIES CKT CAN BE COMBINED WITH OTHER SERIES COMPONENTS TO FIND THE TOTAL IMPEDANCE.

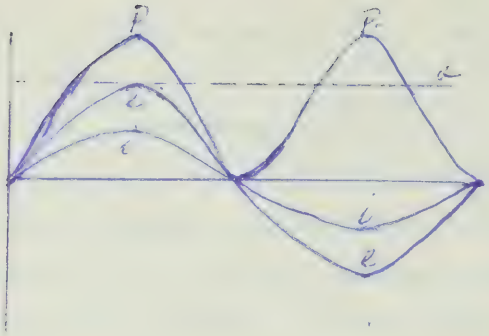
11 DRAW VECTORS DIAGRAMS TROUGH OUT TO HELP UNDERSTAND THE CKT CONDITIONS.

POWER IN A.C. CKTS

IN D.C. CKTS $P = I^2R$, ENERGY CONSUMED BY THE RESISTANCE OR $EI = \frac{E^2}{R}$

IN A.C. IN A PURE RESISTIVE AC. CKT THE POWER CONSUMED IS ALSO IN THE RESISTANCE

THE RELATIONSHIPS OF CURRENT, VOLTAGE AND POWER IN A RESISTANCE ARE SEEN BY THE SINE CURVES



THE VOLTAGE & CURRENT IN A RESISTANCE ARE IN PHASE. THE POWER DELIVERED TO THE RESISTANCE AT ANY INSTANT IS REPRESENTED BY THE CURVES p WICH IS THE PRODUCT OF THE INSTANTANEOUS VALUES OF e & i

THE POWER CURVE IS OF SINE WAVE FORM AND IT IS ENTIRELY OBOVE THE AXIS, THERE BEING NO NEGATIVE POWER. ALSO THE POWER SINE GOES THROUGH TWO CYCLES WHILE ONE FOR VOLTAGE AND CURRENT.

SINCE IN A RESISTANCE $P = ei$ (INSTANTANEOUS VALUES) THE POWER IS POSITIVE IN THE NEGATIVE ALTERNATION OF e & i BECAUSE THEY ARE IN PHASE AND BOTH NEGATIVE.

THE MAXIMUM HEIGHT OF THE P CURVE EQUALS =

$$P_{MAX} = E_{MAX} I_{MAX}.$$

THE AVERAGE POWER DELIVERED TO A RESISTIVE LOAD IS REPRESENTED BY THE LINE a

THEREFORE THE ALTERNATING POWER CONSUMED BY A RESISTIVE LOAD EQUALS = $P = EI$ AS IN D.C CKTS. E & I VALUES ARE EFFECTIVE OR RMS VALUES.

THE USUAL OHMS LAW RELATIONSHIPS HOLD TRUE

$$P = EI = I^2R = \frac{E^2}{R},$$

IN A.C. CKTS CONTAINING REACTANCES THERE IS A PHASE ANGLE OR SHIFT BETWEEN CURRENT AND VOLTAGE. THIS PHASE ANGLE SHIFT WILL GIVE A CERTAIN AMOUNT OF NEGATIVE POWER. THAT IS POWER BELOW THE AXIS. THE AMOUNT OF POWER BELOW THE AXIS (NEGATIVE POWER) IS NOT CONSUMED BY THE CKT, BUT IT IS RETURNED TO THE SOURCE. THEREFORE THE ACTUAL POWER CONSUMED BY THE CKT IS THE POSITIVE POWER MINUS THE NEGATIVE POWER

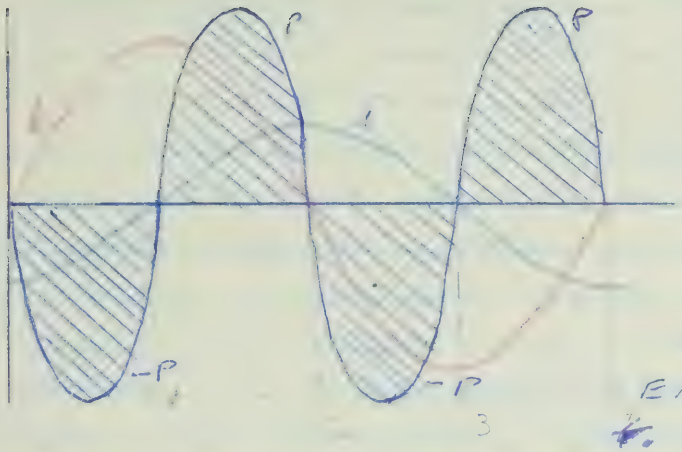


ILLUSTRATION OF THE RELATIONSHIPS OF VOLTAGE, CURRENT & POWER IN A PURE INDUCTANCE. THE VOLTAGE AND CURRENT ARE 90° OUT OF PHASE, THE CURRENT LAGING. THE POWER CURVE GOES THROUGH 2 CYCLES FOR EACH ONE OF VOLTAGE & CURRENT. ALSO IT CAN BE SEEN THAT THE POSITIVE POWER EQUALS THE NEGATIVE POWER. THEREFORE, THERE IS NO POWER CONSUMED IN THE CKT AND ALL OF IT IS RETURNED TO THE SOURCE THEORICALLY THERE IS NO RESISTANCE IN THE CKT. THIS FACT IS ACCOMPLISHED BECAUSE IN PURE REACTANCES THERE IS NO POWER LOSS.

WHEN THE CURRENT IS INCREASING FROM ZERO TO MAX DURING TIME INTERVALS 1-2 POWER IS BEING TAKEN FROM THE SOURCE TO BUILD THE MAGNETIC FIELD (OR ENERGY STORED ABOUT THE COIL). AS THE VALUE OF CURRENT IS DECREASING FROM MAX POSIT. TO ZERO - TIME 2-3. THE MAGNETIC FIELD IS COLLAPSING AND RETURNING IT'S POWER TO THE SOURCE. THUS DURING TIMES 1-2 AND 3-4. THE INDUCTANCE IS TAKING POWER FROM THE SOURCE, (ONCE AS THE CURRENT INCREASES TO A MAX. POSITIVE VALUE AND ONCE AS IT INCREASES TO A MAXI. NEGATIVE VALUE) AND AS IT INCREASES FROM ZERO TO MAX NEGATI TIME 0-1 AND 2-3 IT IS RETURNING THE POWER TO THE SOURCE AS REPRESENTED BY THE NEGATIVE POWER. BETWEEN POINTS 3-4 ALTHOUGH THE VOLTAGE AND CURRENT ARE NEGATIVE THE POWER IS POSITIVE

IN A CAPACITOR AS IN AN INDUCTOR POWER IS NOT LOST OR CONSUMED THEREFORE THE POWER CURVE FOR A CAPACITOR LOOKS LIKE THE CURVE FOR THE INDUCTOR EXCEPT THAT ON THE CAPACITOR THE CURRENT LEADS THE VOLTAGE BY 90° THEREFORE THE POWER PEAKS ARE INVERSED

BUT NEVERTHELESS POSITIVE POWER EQUALS NEGATIVE POWER.

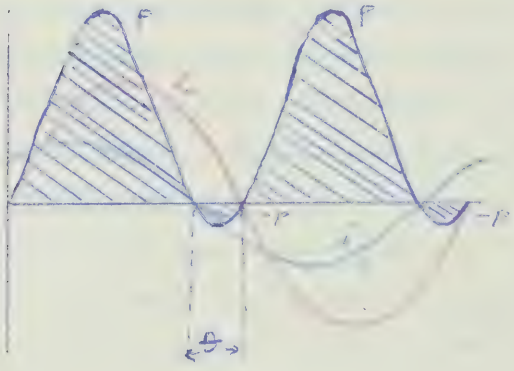
A CAPACITOR STORES ENERGY WHEN THE VOLTAGE IS INCREASING FROM ZERO TO MAXIMUM (POSITIVE OR NEGATIVE) AS THE VOLTAGE DECREASES FROM MAX. TO ZERO IT RETURNS THE POWER TO THE SOURCE.

THE POWER IN REACTIVE CKTS IS CALLED REACTIVE OR APPARENT POWER AND IT IS THE RESUT OF MULTIPLYIN THE VOLT. BY THE CURR.

$P = EI$ AND IT IS MEASURED IN VOLT-AMPERES OR KILOVOLT-AMPERES (VA. OR KVA)

POWER IN A SERIES CKT OF RESISTANCE AND REACTANCE.

IN A CKT CONTAINING BOTH RESISTANCE AND REACTANCE SOME POWER IS CONSUMED AND SOME POWER IS RETURNED TO THE SOURCE



RELATIONSHIPS BETWEEN VOLTAGE CURRENT ANDPOWER.

DUE TO THE RESISTANCE OF THE CKT THE CURRENT IS LEADING THE VOLTAGE BY LESS THAN 90° (PHASE ANGLE θ)

WHEN THE VOLTAGE AND THE CURRENT ARE OF THE SAME SIGN THEY ARE ACTING TOGETHER AND TAKING POWER FROM THE SOURCE. WHEN THEIR SIGNS ARE UNLIKE THEY ARE OPERATING IN OPPOSITE DIRECTIONS AND POWER IS RETURNED TO THE SOURCE.

THE INSTANTANEOUS POWER IS THE PRODUCT OF THE APPLIED VOLTAGE BY THE TOTAL CURRENT OF THE CKT.

OR APPARENT POWER $= EI$

THE ACTUAL POWER TAKEN BY THE CKT IS THE IMPORTANT FACTOR, THAT DETERMINES THE SIZE OF THE GENERATOR IS ALSO CALLED AVERAGE OR TRUE POWER AND IT EQUALS $= I^2R$ OR $E_R I = E_R$ IS THE VOLTAGE ACROSS THE RESISTOR

APPARENT POWER IS: THE POWER THAT THE GENERATOR MUST SUPPLY REGARLES OF THE RETURN. AN IT EQUALS

$$P\text{-(APPARENT)} = EI$$

TRUE, ACTUAL OR AVERAGE POWER IS: THE ACTUAL POWER CONSUMED BY THE RESISTANCE IN THE CKT. AND IT EQUALS:

$$P\text{ (AVERAGE)} = I^2R$$

IN REACTIVE CKTS $I = \frac{E}{Z}$

THEN $P_{(AV)} = \frac{E}{Z} \times I \times R$ OR $= EI \times \frac{R}{Z}$

HOWEVER, THE RATIO $\frac{R}{Z}$ IS THE COS OF θ BETWEEN THE CURRENT AND THE VOLTAGE IN THE CKT THEN

$$P_{.av} = EI \cos \theta$$

WHERE; E = EFFECTIVE VALUE ACROSS CKT
I = " " OF I IN THE CKT
θ = PHASE ANGLE OF E & I.
P = ACTUAL OR TRUE POWER.

IF THE θ IS 90° THE COS θ IS ZERO THEREFORE NO POWER CONSUMED, THE CKT IS REACTIVE.
IF THE θ IS ZERO THE COSI IS 1 - THEREFORE ALL POWER IS CONSUMED, THE CKT IS RESISTIVE.

POWER FACTOR IS THE RATIO OF TRUE POWER TO APPARENT POWER OR THE RATIO OF THE RESISTANCE TO THE IMPEDANCE. AND SINCE THE RATIO R/Z = COS OF θ, THE POWER FACTOR MAY BE ANY VALUE FROM 0 TO 1 AND IT MAY BE EXPRESSED IN DECIMAL OR IN PERCENT, TO DESIGNATE THE PERCENTAGE OF APPARENT POWER CONSUMED AS TRUE POWER.
THEREFORE THE COSINE OF THE θ = THE POWER FACTOR.

$$PF = \cos \theta$$

THE POWER FACTOR TELLS THE RELATIVE POWER DISSIPATED.

A P.F OF ONE IS PURE RESISTIVE CKT
" " " LESS THAN ONE IS REACTIVE & RESISTIVE.

FACTS TO REMEMBER:

APPARENT POWER = E(EFFECTIVE) x I(EFFECTIVE)

AVERAGE, TRUE, ACTUAL = I^2R OR $EI\frac{R}{Z}$ OR $EI = \cos\theta$

POWER FACTOR (PF) = RATIO OF TRUE TO APPARENT POWER

$$P.F. = \frac{T.P.}{Ap-P.} \quad OR \quad \frac{R}{Z} \quad OR$$

$$P.F = COS\ OF\ \theta = 100 \cos\theta = \%$$

RESONANCE SERIES - PARALLEL

SERIES CKTS.
X_L VARIES DIRECTLY AS THE FR. X_C VARIES INVERSELY AS THE FR.

$\uparrow X_L$ TF $\downarrow X_C$ $X_L \downarrow$ FV $X_C \uparrow$

IN A SERIES RESONANT CKT $X_L = X_C$ - SINCE BOTH REACTANCES ARE EQUAL AND OPPOSITE THEY CANCEL OUT, LEAVING ONLY THE RESISTANCE TO LIMIT THE FLOW OF CURRENT. ∴ CURRENT IS AT MAXIMUM AND IMPEDANCE AT MINIMUM = $Z = R$.
SINCE THE X_L INCREASES AS THE FR. INCREASES THEREFORE A SERIES TUNED CKT ABOVE RESONANCE IS INDUCTIVE.
THE X_C ~~DROPS AS THE FR~~ INCREASES AS THE FR DECREASES THEN THE CKT BELOW RESONANCE IS CAPACITIVE.

AT RESONANCE THE CURRENT IS IN PHASE WITH THE APPLIED VOLTAGE, THE P.F IS 100%

THE VOLTAGES ACROSS THE REACTANCES ARE EQUAL AND THE MAY BE MUCH LARGER THAN THE APPLIED VOLTAGE. ALSO THEY ARE OPPOSITE.

F.R. AT RESONANCE.

$$X_L = X_C \text{ OR } 2\pi FL = \frac{1}{2\pi FC}$$

MULTIPLYING BOTH SIDES BY F

$$F^2 2\pi L = \frac{1}{2\pi C}$$

DIVIDING BOTH SIDES BY $2\pi L$ = $F^2 = \frac{1}{4\pi^2 LC}$

TAKIN THE $\sqrt{\ }$ OF BOTH SIDES $F = \frac{1}{2\pi\sqrt{LC}}$

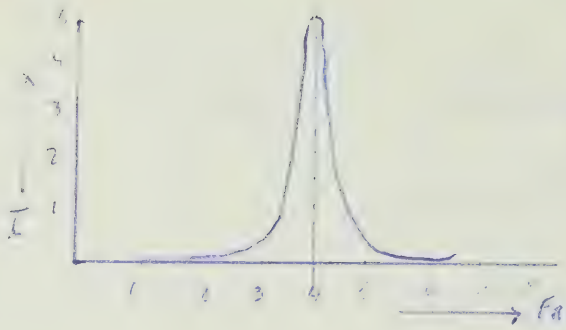
L = IN HENRYS
C = IN FARADS
F = IN C.P.S.

THE RESONANCE FR. DEPENDS ON THE PRODUCT OF L & C ALL OTHER TERMS ARE CONSTANT. THEREFORE THERE MAY BE AN ULIMITED COMBINATIONS OF L & C FOR ANY FR. JUST AS LONG AS THEIR PRODUCT IS THE SAME. IF L IS DOUBLED AND C HALVED THE RESULT WILL BE THE SAME.
ALSO FROM THE FORMULA IT CAN BE SEEN THAT FOR HIGH FR. SMALL VALUES OF L & C WILL BE USED AND VICEVERSA. SINCE IF LC ↑ F↓ OR LC↓ F↑
IF THE VALUE OF L OR C IS KNOWN THE OTHER FACTOR MAY BE FOUND.

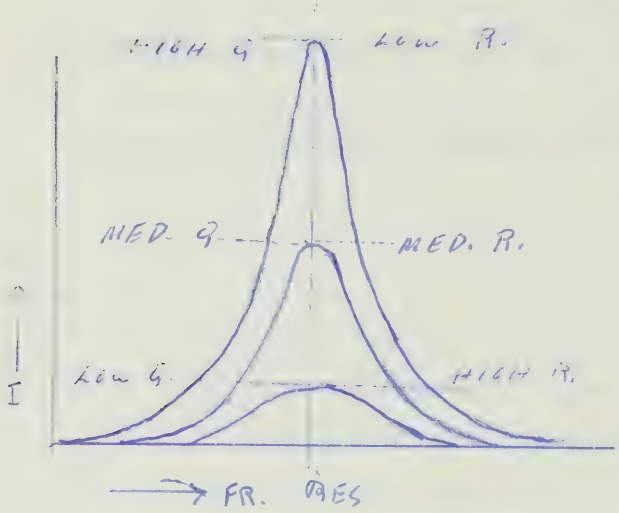
$$F^2 = \frac{1}{4\pi^2 LC} \qquad L = \frac{1}{4\pi^2 F^2 C} \qquad C = \frac{1}{4\pi^2 F^2 L}$$

RESONANCE CURVE FOR SERIES CKT.
THE AMOUNT OF RESIS. IN A CKT DOESNOT HAVE ANY EFFECT ON FR. BUT IT DOES HAVE EFFECT ON THE CURRENT.
THE SMALLER THE RESISTANCE THE GREATER WILL BE THE MAX. CURRENT.

BY GRAPHS WE CAN SEE THE EFFECT OF FR. AND R. IN A SERIES TUNED CKT.



WITH VOLTAGE AND RES. CONSTANT WE SEE THE MAX. I IS AT 4 Kc. OR RESONANT FR. ABOVE OR BELOW RESONANCE THE I CURVE DECREASES THE STEPNESS AND HEIGHT OF THE SLOPE IS DEPENDANT OF THE RESISTANCE.



WITH THE VOLTAGE AND L & C CONSTANT BUT DIFFERENT VALUES OF R. AT RESONANCE FR. THE I CURVE SHOWS THIS EFFECTS.

AS R. INCREASES I DECREASES ALSO THE CURVES BECOME FLATER AND BROADER.

Q ON SERIES RES. CKTS.

THE Q IS THE MERIT OF A CKT. OR A MEASURE OF THE SELECTIVITY OF THE CKT.

IT IS ALSO THE RATIO OF THE REACTANCES VOLTAGE TO THE APPLIED VOLTAGE.

$$Q = \frac{E_L}{E} = \frac{E_C}{E} = \frac{IX_L}{IR} = \frac{IX_C}{IR} \quad \text{or} \quad \frac{X_C}{R} = \frac{X_L}{R}$$

THESE SHOW THAT THE Q VARIES INVERSELY WITH THE RESISTANCE. R↑ Q↓ OR R↓ Q↑.

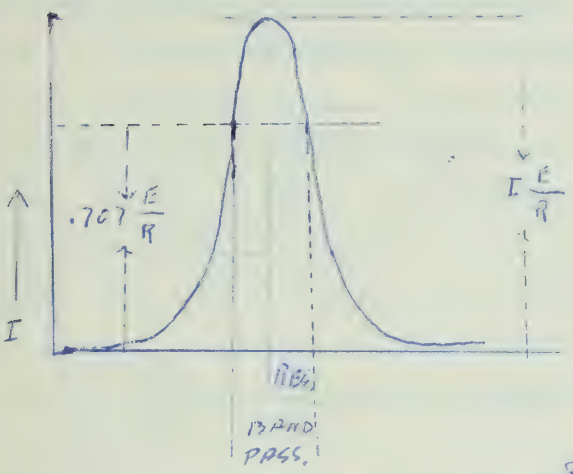
THUS THE Q IS A MEASURE OF THE ABILITY OF THE CKT TO SELECT OR REJECT A BAND OF FR. THE HIGHER THE Q THE GREATER WILL BE. ITS VALUE AS A FR. SELECTOR.

SINCE Q IS THE RATIO $\frac{X_L}{R}$ THE Q = TAN OF ~~θ~~.

ALSO Q IS IN INDICATION OF THE POWER ABSORVED IN THE CKT SINCE

R↑ P↑ Q↓

BAND WITH OR BANPASS OF SERIES TUNED BAND WITH IS THE TOTAL NUMBER OF CYCLES ABOVE AND BELOW RESONANCE WICH REALIZES THE SAME VOLTAGE GAIN AS THE RESONANT FR.
THE WITH OF THIS BAND IS CALLED BAND PASS.



THE EFFECTIVE POINTS OF THE WITH OF THE BAND PASS ARE .707 OF THE MAXI. PEAK OF I AT RES.

THE BAND PASS IS DIRECTLY AFFECTED BY THE Q. IN TERMS OF FR. AT RESONANC, BAND PASS =

$$\text{BAND PASS (CPS)} = \frac{F_{R_0}}{Q}$$

THEREFORE THE Q↑ BANDPASS↓ AND VICEVERSA.
AND IF L↑ AND C↓ THEN X_L r X_C ↓ Q↓ BP↑

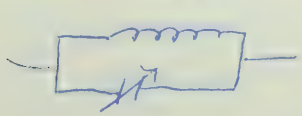
SUMARY OF SERIES TUNE CKTS-
$X_L = X_C$, $E_L = E_C$, $E = E_R$; $Z = R$.
A SERIES TUNED CKT IS ONE IN WHICH THE SIGNAL ORIGINATES WITHIN ITSELF.
I MAX. Z MIN. E_L & E_C MAX.
ABOVE RESONANCE CKT IS INDUCTIVE
BELOW " " " CAPACITIVE.
WILL PASS OR RESECT ONE FR. (BAND).

$$P.F = 1$$

$$Q = \frac{X}{R} = \frac{E_{CL}}{E_R} \qquad B.P. = \frac{F_0}{Q}$$

F↑ X_C↓ X_L↑ $\qquad F_R = \frac{1}{2\pi\sqrt{LC}}$

PARALELL RESONANT CKTS. (TANK CKT)
PARALELL ONE WICH THE SIGNAL ORIGINATES OUTSIDE THE CKT



APLIED VOLTAGE EQUAL TO BOTH BRANCHES.

$X_L = X_C$ THEREFORE $I_L = I_C$ BUT 180° OUT OF PASE.

IF THE REACTANCES ARE PURE THEN- THE PARALELL CKT PRESENTS;

MAXIMUM IMPEDANCE TO THE LINE THERE FORE THE LINE CURRENT IS MINIMUM OR NEAR ZERO.

IF X_C IS LARGER (BELOW RESONANCE) THEN I_L IS GREATER - THE CKT IS INDUCTIVE.

IF X_L IS LARGER (ABOVE RESONANCE) THE I_C IS GREATER. THE CKT IS CAPACITIVE.

THE RESONANCE FR. IS THE SAME AS IN SERIES CKTS

$$F_R = \frac{1}{2\pi\sqrt{LC}}.$$

THE Q IS ALSO THE SAME $= Q \frac{X_L}{R} = \frac{I_{TANK}}{I_{LINE}}$.

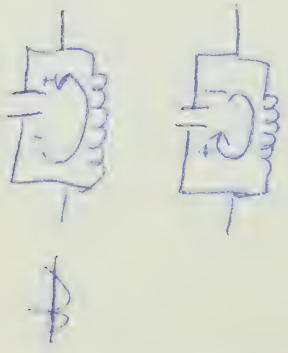
CURRENT WITHING THE TANK.

(FLYWHEEL EFFECT.)

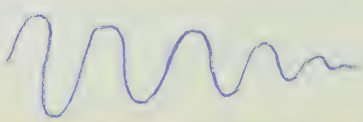
THE LINE CURRENT IS AT MINIMUM BUT THE OSCILLATING CURRENT WITHING THE TANK IS AT MAXIMUM.

THIS CURRENT IS IN PHASE, BOTH ELEMENTS AT CIRCULATES FROM CAP. TO INDUCTOR AND BACK.

WHENT THE TANK IS ENERGIZED BY A PULSE OF CURRENT THE CAP. FIRST CHARGES, THEN DISCHARGES THROUGH THE INDUCTOR, AND IF THERE IS NO LOSS OF ENERGY IT WILL KEEP ON OSCILLATING. WHEN THE CAP. DISCHARGES THE INDUCTOR STORES THE ENERGY AND THEN IT GIVES IT BACK TO THE CAP. THE FR. OF THIS OSCILLATIONS IS DETERMINED BY THE VALUES OF L & C.



SINCE THERE IS RES. IN THE WIRE THE OSCILLATIONS DECREASE UNTIL THERE IS NO MORE CURREN FLOWING



DAMPED WAVES

TO KEEP THE OSCILLATING WAVES GOING ENERGY MUST BE SUPPLY FROM THE OUTSIDE

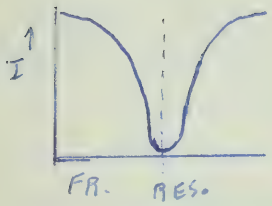
VRRIATION OF THE IMPEDANCE OF A PARALELL CKT WITH FR.

AT ZERO F. Z IS ZERO, THE INDUCTANCE WILL PASS THE CURRENT.

AT RESONANCE. THE Z IS INFINITE.

PASS RESONANCE AS FR. INCREASES THE Z DECREASES, THE CAP. WILL PASS HIGH FR.

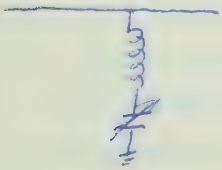
THE RESONANT CURVE OF A PARALELL CKT IS THE INVERSE OF THE SERIES.



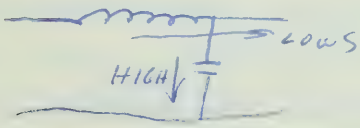
CURRENT IS MAXI BELOW AND ABOVE RESONANCE BUT MINIMUM AT RESONANCE.

APPLICATIONS OF SERIES & PARALELL TUNED CKTS. FILTER CKTS

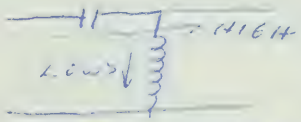
TO PASS ONE BAND OF FR. AND REJECT ALL OTHERS



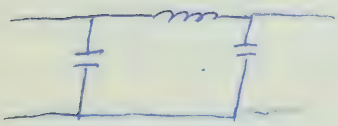
TO BYPASS ONE UNDESIRED FR TO GROUND



LOW PASS FILTER

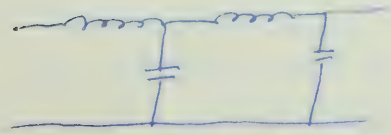


HIGH PASS FILTER.

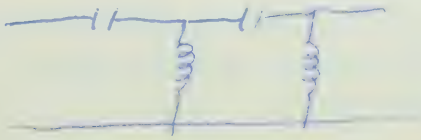


LOW PASS π TYPE

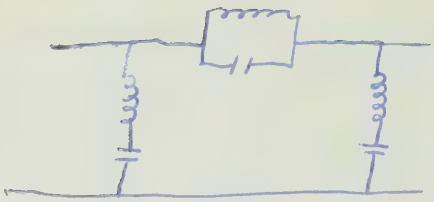
HIGH PASS π TYPE.



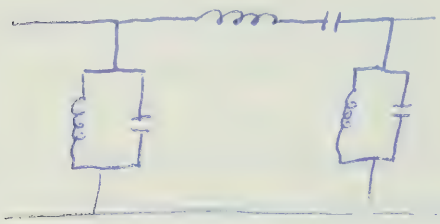
INDUCTOR INPUT LOW PASS π TYPE



CAP. INPUT HIGH PAS π TYPE

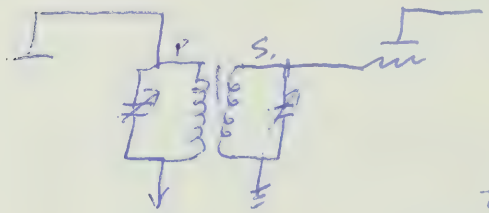


BAN REJECT. ALL CKTS TUNED TO SAME FR. WILL REJECT RESONANCE BAND



BAND PASS. ALL CKTS TUNED TO SAME FR. WILL PASS ONE BAND AND REJECT ALL OTHERS.

THE BAND PASS FILTER USING TRANSFORMERS IS USED IN MANY ELECTRONIC APPARATUS.

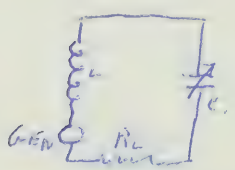


THE PRIMARY AND THE SECONDARY ARE TUNED TO THE SAME FR.

THE TUNED PRIMARY OFFERS HIGH RESISTANCE - BUT LITTLE R. TO THE OSCILLATORY CURRENT WITHIN ITSELF.

THE SECONDARY BEING A SERIES TUNED OFFERS LITTLE RES. TO THIS FR.

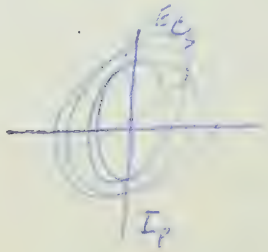
EQUIVALENT CKT FOR THE SECONDARY;



SINCE THE SIGNAL IN THE SECONDARY IS PRODUCED ACROSS THE COIL BY THE MAGNETIC FIELD THEN, THIS ACTION CAN BE REPRESENTED AS A SERIES CKT WITH A GENERATOR WITHIN THE CKT.

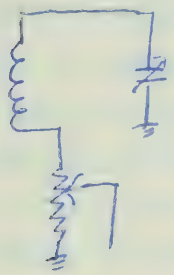
IN THE SECONDARY AT RESONANCE - THE CURRE IS IN PHASE WITH THE INDUCED VOLTAGE, AND 90° OUT OF PHASE WITH THE PRIMARY CURRENT.

THE E ON THE CAP. IS 90° OUT OF PHASE WITH TH PRIMARY VOLTAGE AND IT IS LAGGING.



TO PASS A WIDE BAND OF FR. USING LOW Q CKT, SEVERAL STAGES OF AMPLIFICATION ARE USED.

LOWERING THE Q OF A CKT VARIES THE SENSITIVITY OF THE CKT.



SENSITIVITY CONTROL BY ADDING RESISTANCE LOWERING THE Q.

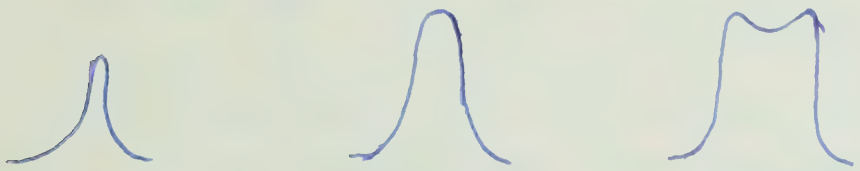
EFFECTS OF COUPLING BETWEEN TUNED PRI- AND TUNED SECONDARY.

COUPLING BETWEEN COILS CAN BE VARIED BY PLACING THE WINDINGS CLOSER OR FURTHER APART.

LOOSE COUPLING - HAVING THE COILS TOO FAR APART, PRODUCES A LOW CURVE.

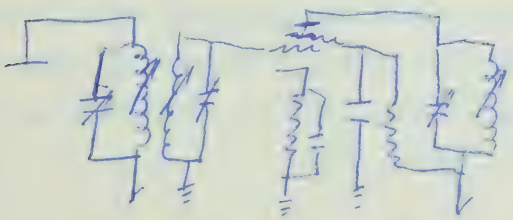
CRITICAL OR OPTIMUM COUPLING. THE POINT THAT PROVIDES THE MAXIMUM TRANSFER OF ENERGY.

OVER COUPLE, TOO CLOSE



LOOSE COUPLING. OPTIMUM COUPLING OVER COUPLING.

R.F AMPLIFIER USING XFORME TUNE - COUPLING.



THE COILS USE A CORE OF POWERED IRON TO TUNED

THEY MAY BE USED WITHOUT THE CAPACITORS, USING THE DISTRIBUTED CAPACI- TANCE TO MAKE THE TUNE CKT.

VOLTAGE GAIN IN AT RESONANCE:

VERY LARGE VOLTAGE ACROSS THE REACTIVE COMPO- NENTS. BECAUSE OF THE LARGE CURRENT, IN THE SERIES CKT

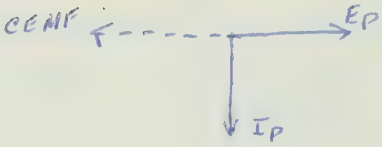
TRANSFORMERS.

TRANSFORMER CAN'T HAVE 100% EFFICIENCY SINCE THERE IS ALWAYS CERTAIN LOSES OF FLUX AND RESISTANCE IN THE WIRE.

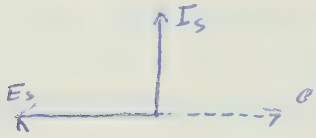
100% COULD BE ACCOMPLISHED WITH NO INDUCTANCE IN THE PRIM. OR SECONDARY.

PHASE RELATIONSHIP OF E & I IN A XFORMER.

E & AND I IN PR. 90° OUT OF PHASE - I LAGING ~~THAN~~ THE CEMF INDUCED IN THE PRIMARY IS 180° OUT OF PHASE WITH* THE APPLIED VOLTAGE AND 90° OUT OF PHASE WITH THE CURRENT I_p



THE VOLTAGE INDUCED IN THE SECONDARY IS OF THE SAME PHASE THAT THE CEMF IN THE PR.
THE SECONDARY E AND I_s ARE 90° OUT OF PHASE I_s LAGING.

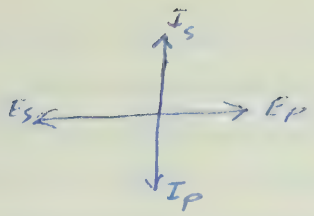


THE INITIAL DIRECTION OF THE E_s IS THE SAME AS THE CEMF IN THE PR.

THE I_s SETS UP AN CEMF OF ITS OWN. 180° OUT OF PHASE WITH THE E_s. THIS CEMF$_s$ INDUCES A VOLT IN THE PR. WHICH IS IN PHASE WITH E_p THEREFORE THE EFFECT OF THE CEMF$_s$ IS TO CANCEL TO SOME EXTENT THE CEMF IN THE PR. ALLOWING MORE CURRENT TO FLOW IN THE PR.

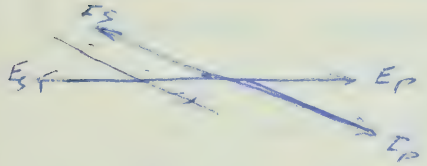
WITH A VERY SMALL LOAD IN THE SECONDARY THE E_p & E_s ARE 180° OUT AND I_p I_s ALSO 180° OUT WITH THE CURRENTS ~~LEADING~~ LAGING THEIR RESPECTIVE VOLTAGES BY 90°

I_p



HOWEVER IF THE LOAD RESISTOR IN THE SECONDARY IS DECREASED MORE CURRENT WILL FLOW AND THE CKT BECOMES MORE RESISTIVE. THE ANGE OF E_s - I_s DECREASES. IF THE LOAD KEEPS INCREASING THE CKT APPROACHES THE IN PHASE CONDITION OR $\theta = 0°$.

SINCE THE I_p INCREASES AS THE I_s INCREASES, THE X_L OF THE PR. HAS BEEN REDUCED, THEREFORE THE CKT APEARS MORE RESISTIVE IN THE PRIMARY ALSO



THE VECTORS SHOW THE θ OF A XFORMER.

AN IDEAL XFORMER WOULD SHOW THE I VECTORS SUPERIMPOSED IN THE E VECTORS FOR 100% EFFICIENCY. THAT IS E + I IN EACH SIDE IN PHASE, AND 180° OUT OF PHASE WITH THE OTHER SIDE.

TURNS RATIO: VOLTAGE.

THE MAGNITUD OF AN INDUCED EMF DEPENDS PARTLY IN THE NUMBER OF TURNS IN THE COIL

RATIOS: $\frac{E_p}{N_p} = \frac{E_s}{N_s}$ OR $\frac{E_p}{E_s} = \frac{N_p}{N_s}$

TURNS RATIO: CURRENT

IN TRANSFER OF ~~POWER~~ ENERGY, THE POWER OBSORBED BY THE SECONDARY MUST EQUAL THE POWER ABSORBED BY THE PR. (IN IDEAL XFORMER)

$P_s = P_p \quad \therefore P.F = 1 \; ; \; \theta = 0°$

POWER ON EITHER SIDE EQUALS $P_s = E_s I_s$; $P_p = E_p I_p$

THEN $E_p I_p = E_s I_s$ OR $\frac{I_p}{I_s} = \frac{E_s}{E_p}$

THE RATIO $\frac{E_p}{E_s} = \frac{N_p}{N_s}$ THEN $\frac{I_p}{I_s} = \frac{N_s}{N_p}$

POWER XFORMERS! TO CONVERT THE POWER OUTPUT FROM GENERATORS TO HIGH VOLTAGE LOW CURRENT LEVEL. AND THEN CONVERTS IT TO LOW VOLTAGE, HIGH CURRENT FOR HOME USE.

POWER XFORMERS SHOULD BE OPERATED AT AT LERS 90% OF THEIR RATED LOAD OR AS CLOSE TO A P.F OF 1. IF OPERATED AT LESS THAN HALF, THEY SHOW LARGE AMOUNT OF X_L IN BOTH WINDINGS, AND THE INDUCED VOLTAGES ARE VERY HIGH. UNDER FULL LOAD THE X_L OF THE PRIMR. IS ALMOST CONCELLED BY THE INDUCED VOLT. SET UP BY THE SEC. THE PHASE θ IS SMALL MAKING P.F IS CLOSE TO 1

COMERCIAL POWER XFORMERS HAVE A P.F OF .9 AND EFFICIENCY OF 95%

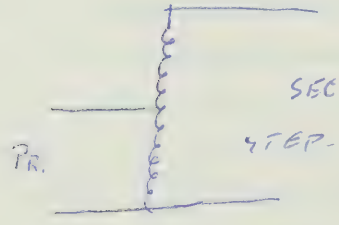
EFFICENCY OF A XFORMER IS THE RATIO OF TRUE POWER OUT TO TRUE POWER IN

$$EFF. \quad \frac{TP_{OUT}}{TP_{IN}}$$

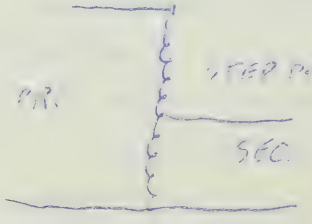
POWER XFORMERS WITH MORE THAN ONE SECONDARY WINDING, THE TOTAL TP_{OUT} IS THE SUM OF THE SECONDARY WINDINGS.

AUTO XFORMERS! OR SELF XFORMER. A SPECIAL KIND OF POWER XFORMER DESIGNED FOR GOOD VOLTAGE REGUARTION.

STEP UP AUTOXFORMER



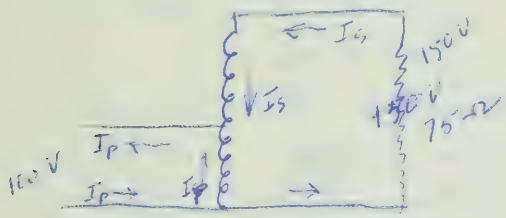
ALL OF PRIMARY WINDING IS PART OF THE SECONDARY WINDING.



ALL SECONDARY TURNS ARE PART OF PRIMARY

VOLTAGES ACROS THE INDIVIDUAL WINDING FOLLOW THE TURNS RATIOS. BUT SOME TURNS ARE COMON TO BOTH WINDINGS.

THE CHIEF ADIANTAGE OF OUTO-XFORMERS IS THAT THE LOAD CAN BE VARIED WITHOT HAVING ARCING ACROSS THE TURNS, LIKE THE NORMAL POWER XFORMER, WITH A VERY LITTLE CHANGE IN VOLT. THIS RESULT IS DEPENDENT ON THE FACT THAT THE PRIMARY AND SECONDARY CURRENT ARE 180° OF PHASE, AND THEIRE FORE TEND TO CANCEL EACH OTHER IN THE PART OF THE XFORMER WHICH IS COMMON TO BOTH WINDINGS.

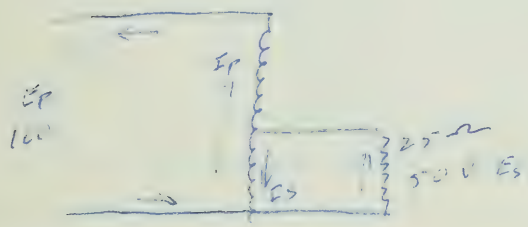


RATIO 1 TO 1½
PRIMARY VOLTAGE 100 V
SECONDARY VOLT. 150 V
SECONDARY LOAD 75 Ω

$$I_s = \frac{150}{75} = 2.$$

BY THE TURNS RATIO FORMULA. I_p SHOULD BE 3 AMPS, HOWEVER SINCE I_s & I_p ARE 120° OUT OF PHASE THE TOTAL I_p IS THE ALGEBARIC SUM OF THE TWO OR 1 AMP.

IN A STEP DOWN THE SAME RELATIONSHIPS HOLD TRUE



E_p = 100 V
E_s = 50 V
R_L = 25 Ω
TURNS RATIO 1 TO 2

I_s = ~~1 AMP~~ 2 AMP

I_p SHOULD BE $\frac{I_p}{I_s} = \frac{N_s}{N_p}$ OR $\frac{I_p}{2} = \frac{50}{100}$ = I_p = ~~1~~ 1 AMP

THUS THE I_p IN THE PART OF THE PR. COMMON TO THE SEC. IS 1 AMP FLOWING IN THE DIRECTION OF THE SECOND.

THIS TYPE OF XFORMERS ARE USED TO VARY THE LINE VOLTAGE, TO KEEP A GIVEN OUTPUT VOLT. AT A RATED LOAD

TURNS RATIO: IMPEDANCE.

THE IMPEDANCE RELATIONSHIP OF A XFORMER IS NOT EQUAL TO THE TURNS RATIO BUT TO THE SQUARE OF THE TURNS RATIO.

THE Z OF THE SECONDARY IS USUALLY THE LOAD (RESISTIVE)

THE Z OF THE PRIMARY CKT IS DIRECTLY PROPORTIONAL TO THE SQUARE OF THE RATIO OF TURNS OF THE PRIMARY TO THE TURNS OF THE SECONDARY

$$\frac{Z_P}{Z_S} = \frac{N_P^2}{N_S^2}$$

PROOF: $\frac{E_P}{E_S} = \frac{N_P}{N_S}$ $\quad$ $\frac{I_P}{I_S} = \frac{N_S}{N_P}$

DIVIDING ONE BY THE OTHER $\quad \frac{\frac{E_P}{I_P}}{\frac{E_S}{I_S}} = \frac{N_P^2}{N_S^2}$

BUT $E_P/I_P = Z_P$ AND $E_S/I_S = Z_S$

THEREFORE $\left(\frac{Z_P}{Z_S} = \left(\frac{N_P}{N_S}\right)^2\right.$

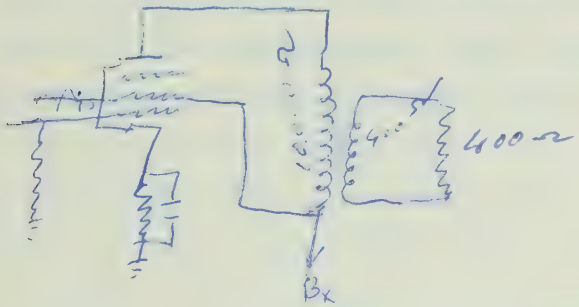
THEN $Z_P = Z_S \times \left(\frac{N_P}{N_S}\right)^2$ OR $Z_S = Z_P \times \left(\frac{N_S}{N_P}\right)^2$

OR $\frac{N_P}{N_S} = \sqrt{\frac{Z_P}{Z_S}}$

IMPEDANCE MATCHING

FOR A MAXIMUM TRANSFER OF POWER FROM ANY ELECTRICAL SOURCE TO ~~IS~~ IT'S LOAD THE IMPEDANCE OF THE LOAD MUST EQUAL OR MATCH THE IMPEDANCE OF THE SOURCE.

IMPEDANCE MATCHING CAN BE ACCOMPLISHED BY A XFORMER. EXAMPLE: TO MATCH A LOW IMPEDANCE LOAD TO A HIGH IMPEDANCE SOURCE. THE OUTPUT STAGE OF AN AMPLIFIER



THE Z OF THE TUBE IS 10,000 Ω. AND THE LOAD IS 400 Ω. THE PRIMARY Z IS TO MATCH THE SOURCE, THE Z_S IS TO MATCH THE LOAD

THE TURNS RATIO OF THE XFORMER IS:

$$\frac{N_P}{N_S} = \sqrt{\frac{Z_P}{Z_S}} = \sqrt{\frac{10{,}000}{400}} = \sqrt{\frac{25}{1}} = \frac{N_P}{N_S} = \frac{5}{1}$$

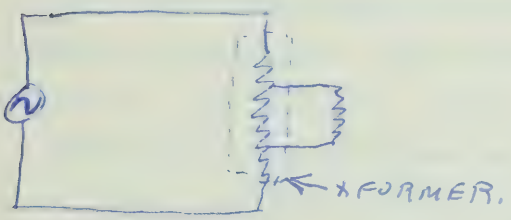
IF 100 V ARE APPLIED TO THE PRIM. THE E_S IS 20 V. THE I_S IS .05 AMP. THE I_P IS $\frac{100}{10{,}000} = .01$ AMP.

$P_P = 100 \times .01 = 1$ WATT

$P_S = 20 \times .05 = 1$ WATT

SINCE BOTH THE P_P & P_S ARE EQUAL THE XFORMER HAS MATCHED A HIGH Z SOURCE TO A LOW Z LOAD

EQUIVALENT CKT



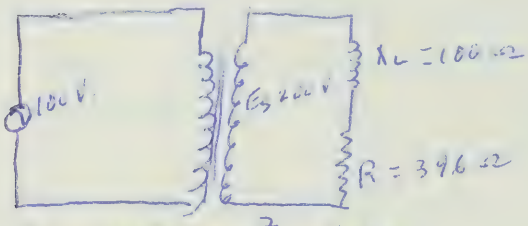
IT CAN BE SAID THAT THE SOURCE SEES THE Z_P AS MATCHING Z AND THE SECONDARY WHICH BY XFORMER ACTION RECEIVES THE POWER OF THE PRIMARY, SEES THE LOAD Z AS THE MATCHING Z.

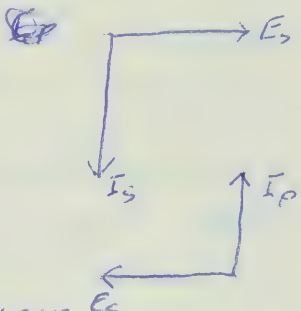
REFLECTED IMPEDANCE:

IF THE LOAD ON THE SECONDARY IS A PURE RESISTANCE, THE LOAD APPEARS TO THE SOURCE AS A RESISTANCE. BUT WITH THE VOLTAGE AND CURRENT DISPLACED 180° & BECAUSE OF THIS PHASE SHIFT IT IS SAID THAT THE LOAD IS REFLECTED TO THE

PRIMARY. IF THE LOAD IS RESISTIVE THEN ALL WE HAVE IS REVERSE POLARITY. BUT IF THERE IS SOME REACTANCE IN THE LOAD THEN THERE IS A CERTAIN PHASE ~~Θ~~ IN THE SECONDARY WHICH IS ALSO REFLECTED BACK TO THE PRI.

BECAUSE THE REACTIVE COMPONENTS OF IND. AND CAP. ACT IN OPPOSITE MANER, 180° OUT OF PHASE, THEN THE EFFECT OF AN X_L IN THE LOAD IS TO REFLECT A X_C IN SERIES WITH THE PRI. THE EFFECT OF AN X_C IS TO REFLECT AN X_L IN SERIES WITH THE SECONDARY.

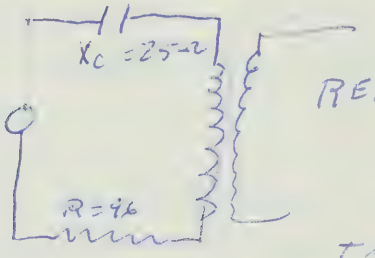




E_S IS LAGGING THE E_S BY 90°

I_P IS LAGGING E_P BY 90°

E_S I_S ARE 180° OUT OF PHASE WITH E_P I_P.



REFLECTED Z

HERE 100Ω X_L IN THE SECONDARY IS REFLECTED BACK AS 25 Ω X_C IN SERIES DUE TO THE I_S LAG.

THE REFLECTED X_C CANCELS PART OF THE X_L IN THE PRIMARY, BUT THE OVER-ALL LEADING ~~PH~~ OF THE ~~E~~ I_P IS NOT GREATLY AFFECTED.

THE DIAGRAM SHOWS THE EFFECTS OF AN X_L IN THE LOAD. THE SAME BUT OPPOSITE EFFECT IS ACCOMPLISHED BY A CAP. IN THE LOAD.

SINCE INDUCTANCES AND CAP. ACT IN OPPOSITE WAYS THE ADDING CAP. IN SERIES TO A CKT IS LIKE ADDING INDUCTANCE IN PARALELL AND VICE-VERSA.

SO HAVING AN X_C REFLECTED TO THE PRIMARY REDUCES SOME WHAT THE INDUCTANCE PRESENT, THIS IS THE SAME AS PUTTING ANOTHER INDUCTOR IN PARALELL, SINCE THE TOTAL INDUCTANCE OF ~~THE~~

INDUCTORS IN PARALELL IS LESS THAN ANY OF THEM.

THEN A CAP. IN THE SEC. WILL REFLECT AN INDUC-
TANCE IN SERIES TO THE PRIMARY, AND THIS EFFECT
IS TO ADD REACTANCE TO THE PRIMARY, THE IT WILL
ACT AS A CAP. IN PARALELL WITH THE PRIMARY
INDUCTANCE.

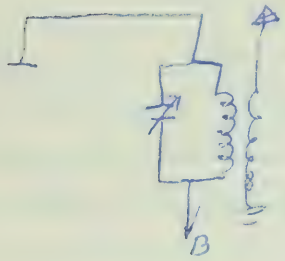
A CAPACITANCE IN THE SECONDARY, REFLECTS IT CAP-
ACROSS THE PRIMARY INVERSELY PROPORTIONAL TO
THE SQUARE OF THE NUMBER OF TURNS.
AN INDUCTANCE IN THE SECONDARY REFLECTS IT'S
INDUCTANCE ACROSS THE PRIMARY DIRECTLY PROPOR-
TIONAL TO THE SQUARE OF THE NUMBER OF TURNS

SO REACTANCES IN THE SECONDARY CAUSES THE MAG-
NETIC EFFECT TO BE LEADING OR LAGGING THE Φ Ip SO
THE CEMF WILL BE ~~LEAD~~ LAGGING OR LEADING

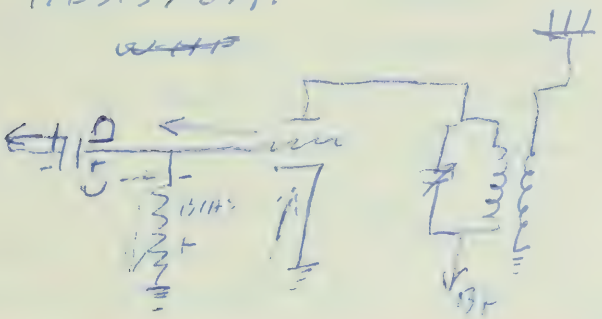
AUDIO FR. XFORMERS ARE HIGH INDUCTANCE, IRON-
CORE, USED AS POWER TRANSFER AND IMPEDANCE
MATCHING DEVICES AT FREQ. BETWEEN 20 - 20,000 CPS.

A MICROPHONE XFORMER MATCHES A LOW Z MIKE
TO A HIGH Z OF THE INPUT TO A TUBE.

R.F POWER STAGE.
USING A TUNED CKT.

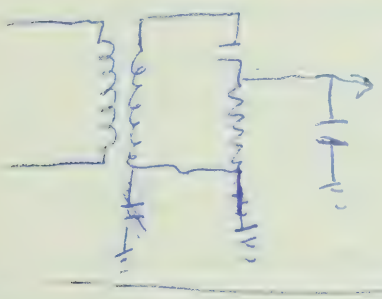


SINCE THE GRIDS OF AN R.F. POWER AMPLIFIER ARE DRIVEN POSITIVE WHEN OPERATING CLASS C OR B THE BIAS FOR THE TUBE MAY BE DEVELOPED ACROSS THE GRID RESISTOR.



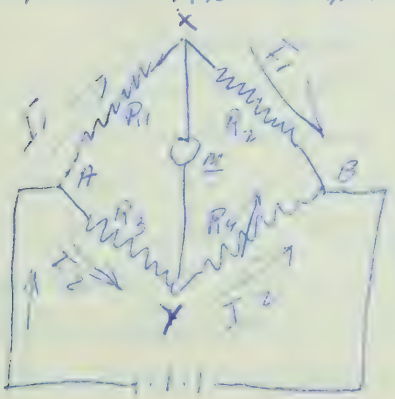
GRID LEAK BIAS
IN THE POSITIVE HALF OF THE GRID DRAWS CURRENT CETING UP A NEGATIVE TO POSITIVE POLARITY IN THE GRID RESISTOR, EFFECTIVELY DEVELOPING THE BIAS.

DIODE DETECTOR



THE AUDIO OUTPUT IS RECTIFIED BY THE TUBE. AND PICK UP ACROSS THE RESISTOR. THE CAPACITOR IS TO SHORT OUT ANY R.F.

THE WHEATSTONE BRIDGE.
TO MEASURE UNKNOWN VALUES OF R, L. AND C. FOR RESISTANCE



R_1 & R_2 ARE RESISTORS WHICH ARE KNOWN. R_3 IS THE UNKNOWN AND R_4 IS A CALIBRATED VARIABLE TO BALANCE THE METER. AND FIND THE UNKNOWN RESISTANCE

A CURRENT IS FED TO THE BRIDGE AT POINTS A & B. THEN R_4 IS ADJUSTED UNTIL

THE METER IS BALANCED OR NO CURRENT FLOWIN[G] TROUGH IT, WHICH INDICATES THAT POINTS X & Y ARE AT THE SAME POTENTIAL.

THE TOTAL CURRENT DIVIDES AT "A" INTO I_1 AND "I_2". IF THERE IS NO POTENTIAL DIFFERENCE BETWEEN X & Y THAT MEANS THAT THE VOLTAGE DROP ACROSS R_1 IS EQUAL TO R_3

THUS $I_1 R_1 = I_2 R_3$

AND $I_1 R_2 = I_2 R_4$

DIVIDING. OR $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

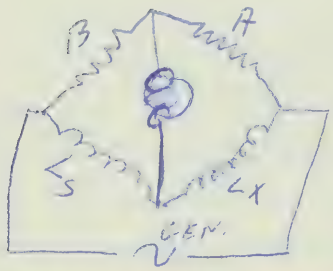
IF R_1 & R_2 ARE EQUAL

THEN $1 = \frac{R_1}{R_2}$ OR $1 = \frac{R_3}{R_4}$

OR $R_3 = R_4$ (FOR $R_1 = R_2$)

AND TO FIND THE VALUE OF THE UNKNOWN R_x ACCURACY ADJUST R_4 FOR NO CURRENT THROUGH THE METER, — R_1 AND R_2 ARE KNOWN AS THE RATIO ARMS

TO MEASURE INDUCTANCES



RESISTANCES ARE USED AS THE RATIO ARMS. WHEN THERE IS NO SOUND IN THE PHONES THE INDUCTANCES ARE EQUAL IF THE RATIO ARMS ARE EQUAL. IF THE RATIO ARMS ARE NOT EQUAL THEN $L_X = L_S \times \frac{A}{B}$

L_S IS USUALLY THE KNOWN STANDARD. TO WHICH THE UNKNOWN IS TO BE COMPARED. ONE OF THE RATIO ARMS MUST BE ADJUSTABLE. UNLESS L_S IS ADJUSTABLE.

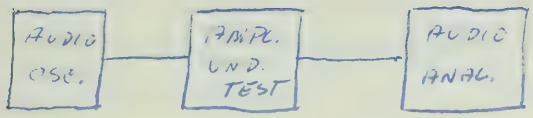
THE METHOD FOR CAPACITOR IS THE SAME.

INSTEAD OF THE EARPHONES A METER WITH A RECTIFIER COULD BE USED AND IT WOULD BE BALANCED TO NO CURRENT FLOW.

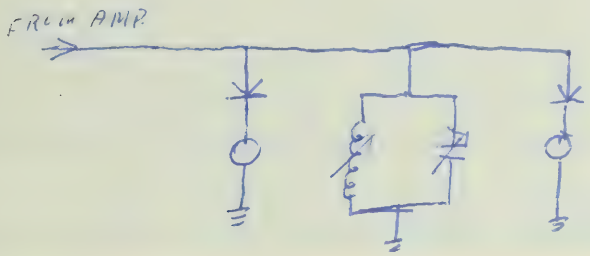
THE RATIOS OF THE COMPONENTS TO MAKE POINTS X & Y EQUAL MUST BE THE SAME.

THE HARMONIC DISTORTION ANALIZER.

SET UP:



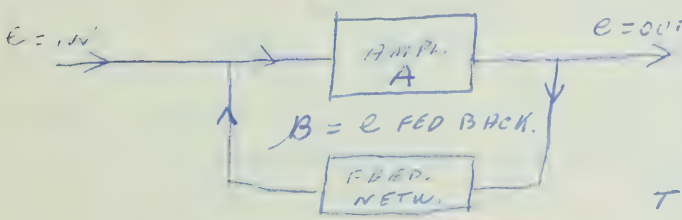
HARMONIC DISTORTION ANALIZERS, BY MEANS OF TUNED CKTS, REMOVE THE FUNDAMENTAL FR. AND MEASURE THE STRENG OF THE HARMONICS (SECOND HARMONIC).



MEASURES THE INPUT.
BYPASSES THE FUNDAMENTAL TO GROUND.
MEASURES THE OUTPUT AND COMPARIES IT TO THE INPUT IN PERCENT.

FEED BACK. (TRANSFER OF ENERGY FROM THE OUTPUT CKT TO THE INPUT)
TWO KINDS, POSITIVE & NEGATIVE OR INVERSE.
(REGENERATIVE) (DEGENERATIVE)

POSITIVE OR REGENERATIVE IS WHEN THE FEEDBACK IS IN PHASE WITH THE APPLIED SIGNAL SO IT AIDS.
NEGETIVE OR DEGENERATIVE IS WHEN THE FEEDBACK IS 180° OUT OF PHASE WITH THE SIGNAL SO IT OPPOSES, ALSO TO KEEP THE GAIN DOWN AND STEADY.
PRINCIPLE OF FEEDBACK.



A PORTION B OF THE OUTPUT VOLTAGE IS FEEDBACK TO THE INPUT.
THE GAIN OF SUCH AN AMPLI. IS $\text{GAIN} = \frac{A}{1 - BA}$
WHERE A IS THE GAIN OF THE AMPLIFIER WITHOUT FEEDBACK.
AND B (beta) IS THE PORTION OF VOLTAGE FED BACK OR THE FEED BACK FACTOR.

POSITIVE FEEDBACK. IF THE FEEDBACK VOLTAGE IS IN PHASE WITH THE INPUT SIGNAL TO THE AMPL. AND IF THE QUANTITY $1-BA$ IS LESS THAN 1, THE TOTAL GAIN WILL INCREASE AND ANY DISTORTION WITHIN THE AMPL. WILL ALSO BE AMPLIFIED. AND IT WILL REACH A POINT WHERE IT BEGINS TO OSCILLATE.

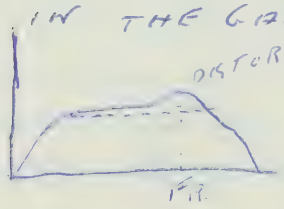
POSITIVE FEEDBACK IS NOT USED IN DISTORTIONLESS AMPLIFIERS IT IS USED IN OSCILLATORS.

NEGATIVE FEEDBACK: IF THE VOLTAGE FED IS 180° OUT OF PHASE AND THE PRODUCT $1-BA$ IS GREATER THAN ONE, IT IS NEGATIVE FEEDBACK OR DEGENERATIVE

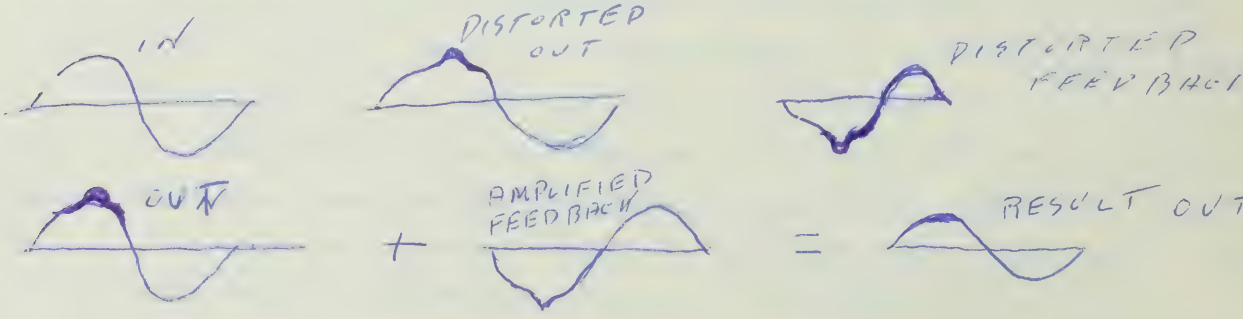
DEGENERATIVE FEED BACK REDUCES THE DISTORTION WITHIN THE AMPL.

FEED BACK WILL NOT REDUCE NOISE OR DISTORTION WHICH IS PRODUCED OUTSIDE THE FEED BACK LOOP.

IF THE GAIN AT SOME FR. IS HIGHER THAN AT OTHER FR. THEN MORE VOLTAGE IS FED BACK. THE RESULT IS THAT THERE ~~IS EVEN MORE GAIN IN PROPORTION THAN BEFORE.~~ IS A CUT IN THE GAIN OF THE AMPL. ELIMINATING THE DISTORTION



DOTTED LINE SHOWS HOW ~~OF~~ NEGATIVE FEEDBACK CAN CUT DOWN THE DISTORTION AT SOME FR. BY CUTTING DOWN THE GAIN.



IF NEGATIVE FEED BACK IS OBTAIN THROUGH A RESISTIVE NETWORK, THE FREQUENCY RESPONSE CAN BE IMPROVED BUT ONLY WITHIN THE FEED BACK LOOP.

SINCE MOST OF THE DISTORTION IS CAUSED BY THE OUTPUT POWER STAGES, THE GAIN LOST CAN BE MADE UP IN THE LOW LEVEL STAGES.

THE USE OF NEGATIVE FEED BACK IS

1 TO REDUCE FR. DISTORTION

2 TO ~~.1~~ VARIATIONS IN THE GAIN, CAUSED BY B+ ~~OR~~ CIRCUIT COMPONENTS VARIATIONS.

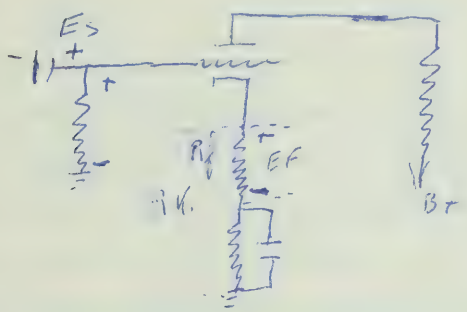
3 TO REDUCE NOISE AND HUM PRODUCED IN THE AMPL.

METHODS OF USING DEGENERATIVE FEEDBACK.

CURRENT & VOLTAGE METHOD.

CURRENT:

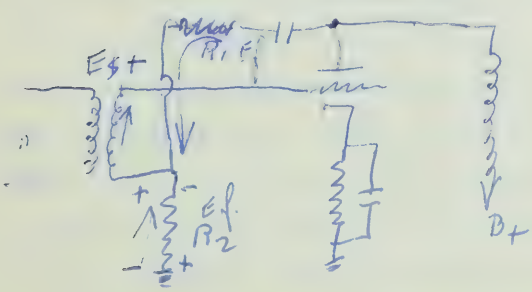
SELF BIASED AMPLIFIER. BY REMOVING THE BY-PASS CONDENSER FROM PART OF THE CATHODE RESISTOR. THE A.C VOLT. ACROSS R_f IS 180° OUT OF PHASE WITH THE INPUT SIGNAL.



WHEN THE PLATE CURRENT INCREASES, IT PRODUCES THE VOLTAGE DROP E_f. SINCE THIS VOLTAGE IS IN SERIES WITH THE E_s THE TOTAL CATHODE-GRID VOLTAGE IS $E_s - E_f$. SINCE E_f IS 180° OUT OF PHASE, MAKING THE GRID MORE NEGATIVE RELATIVE ~~WITH~~ TO THE CATHODE. THEREFORE DEGENERATION OCCURS.

VOLTAGE.

VOLTAGE DIVIDER METHOD:

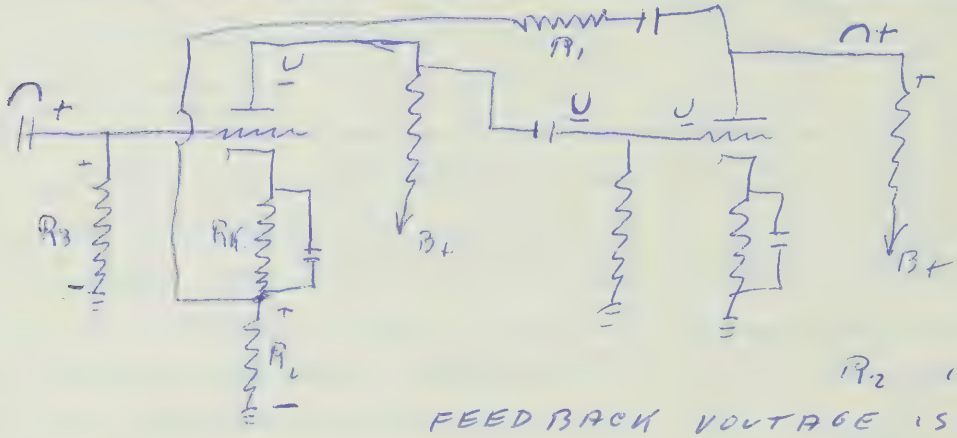


PART OF THE O.P. VOL. IS FED BACK THROUGH THE BLOCKING CAP. AND THE RESISTOR.

WHEN THE GRID IS GOING LESS NEGATIVE THE I_p IS INCREASING CAUSING THE E_p TO DROP, THIS DECREASES IS FEED BACK TO R_2 MAKING THE TOP OF R_2 MORE NEGATIVE, THUS ADDING A NEGATIVE GOING FEED BACK VOLTAGE TO THE POSITIVE GOING GRID.

THERE IS MANY METHODS OF USING NEGATIVE FEED BACK, COVERING ONE TUBE OR THE WHOLE AMPLIFIER. WHEN USING FEEDBACK IN MORE THAN ONE STAGE, THE PHASE SHIFT IN EACH TUBE MUST BE TAKEN INTO CONSIDERATION TO MAKE SURE THE SIGNAL FED BACK IS IN THE PROPER PHASE

TWO-STAGE DEGENERATIVE AMPLIFIER.



R_1 & R_2 FORM THE VOLTAGE DIVIDER TO PEAK THE RIGHT VALUE OF FEEDBACK VOLTAGE

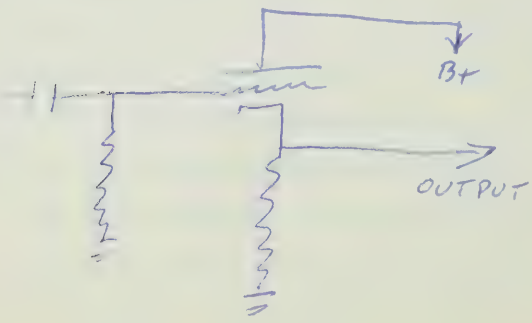
R_2 IS WHERE THE FEEDBACK VOLTAGE IS DEVELOPED

IF A POSITIVE SIGNAL COMES TO THE GRID OF TUBE 1 THE GRID OF TUBE BECOMES MORE NEGATIVE (180° PHASE) MAKING THE E_P ON TUBE 2 TO GO POSITIVE. THIS POSITIVE POTENTIAL IS FEEDBACK TO R_2 WHICH IN TURN PEAKS SOME OF IT, MAKING THE CATHODE OF TUBE 1 MORE POSITIVE WITH RESPECT TO GROUND, THEREFORE MAKING THE GRID MORE NEGATIVE, CAUSING DEGENERATION

IN AUDIO SINCE MOST OF THE DISTORTION IS CAUSED IN THE POWER OUT PUT STAGE, THE FEED BACK IS TAKEN FROM THE SECONDARY OF THE OUTPUT X-FORMER.

CATHODE FOLLOWER.

THE OUTPUT IS NOT TAKEN FROM THE PLATE BUT FROM THE CATHODE.



SINCE THE OUTPUT IS PART OF THE GRID VOLTAGE THIS CKT IS DEGENERATIVE. OR HAS 100% FEEDBACK

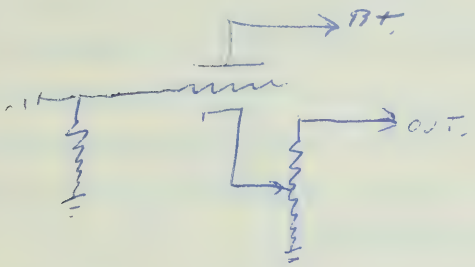
THE VOLTAGE GAIN CAN NEVER BE MORE THAN 1 USUALLY .9 OR .8.

THE CATHODE FOLLOWER IS CAPABLE OF PRODUCING POWER GAIN.

MAINLY IT IS USED AS A MATCHING IMPEDANCE DEVICE SINCE IT HAS A VERY HIGH IMPEDANCE INPUT AND VERY LOW OUTPUT IMPEDANCE (OHMS)

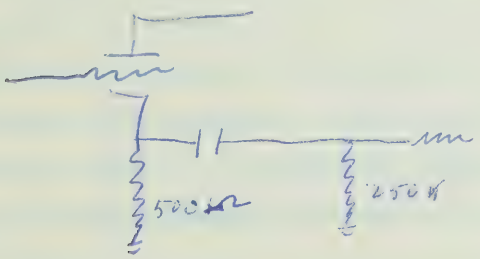
ALSO NO PHASE SHIFT BETWEEN INPUT AND OUTPUT

A CATHODE FOLLOWER WITH A VARIABLE OUTPUT Z.



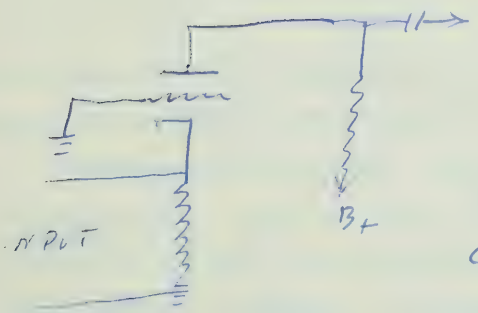
USED TO MACHT DIFFERENT OUTPUT LINES.

TO MATCH THE Z TO A TUBE AND PREVENT THE 60 ~ STRAY FIELDS FROM GETTING IN THE LINE AND GOIN TO NEXT STAGE



THE 60 ~ PICKED UP BY THE LINE WILL SEE A MUCH LOWER RESISTANCE IN THE 500 Ω CATHODE R. THAN IN THE 250K GRID RESISTOR OF THE NEXT STAGE

GROUNDED GRID AMPLIFIER.



THE SIGNAL VOLTAGE IS IN PHASE WITH THE PLATE VOLTAGE.

THE EFFECTS OF INTERELECTRODE CAPACITANCE IS ALMOST ELIMINATED.

THE CHIEF USE OF THIS AMPLIFIER IS AT HIGH FR. WHERE THE INTERELECTRODE CAPACITANCE IS SERIOUS THE GRID BEIND AT GROUND POTENTIAL, PUTS AN ELEC TROSTATIC SHIELD BETWEEN THE ELEMENTS.

DEMODULATION.

DETECTION OF AMPLITUD MODULATED SIGNALS.

AUDIO FR. CAN NOT BE TRANSMITTED THROUGH THE AIR.

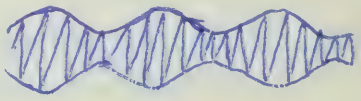
THEY MUST BE CARRIED BY AN R.F WAVE. (CARRIER) THIS IS DONE BY SUPERIMPOSING THE A.F ON THE R.F. CALLED MODULATION

AMPLITUD MODULATION: THE AMPLITUD OF THE R.F. IS MADE TO VARY AT THE AUDIO RATE.

TO RECEIVE THE AUDIO FR. IN THE RECEIVER, THE A.F. MUST BE EXTRATED FROM THE R.F. CALLED DEMODULATION OR DETECTION.

AUDIO WAVE

R.F. WAVE



A.M. R.F WAVE.

THREE STEPS TO DETECTION OF A.M. SIGNALS

1 RECTIFICATION: SINCE THE POSITIVE AND NEGATIVE HALVES OF THE WAVE ARE EQUAL, ONE SIDE MUST BE ELIMINATED TO PREVENT BOTH SIDES FROM CANCELLING EACH OTHER.

2 FILTERING: THE R.F. MUST BE ELIMINATED IF THE AUDIO ALONE IS TO BE USED, SO THE R.F. CURRENTS ARE FILTERED AND BY-PASSED TO GROUND.

3. BLOCKING OF THE D.C. VOLTAGES: THE D.C. PRODUCE IN THE CIRCUIT MUST BE BLOCKED FROM THE AUDIO SECTION DONE BY A BLOCKING OR COUPLING CAP.

RECTIFIED

R.F. FILTERED

D.C. BLOCKED.

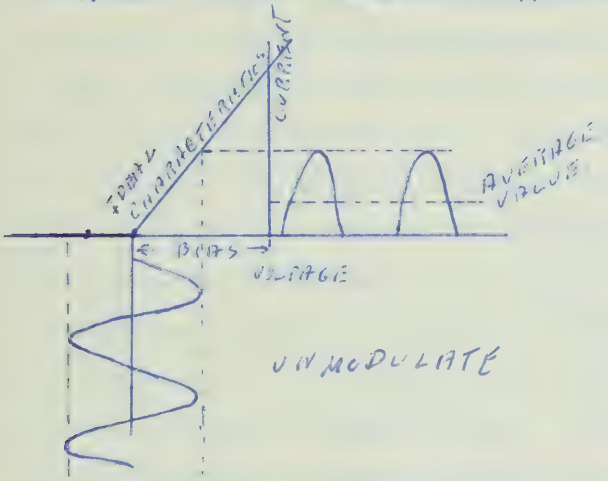
METHODS OF DETECTION.

~~DIODE DETECTOR~~

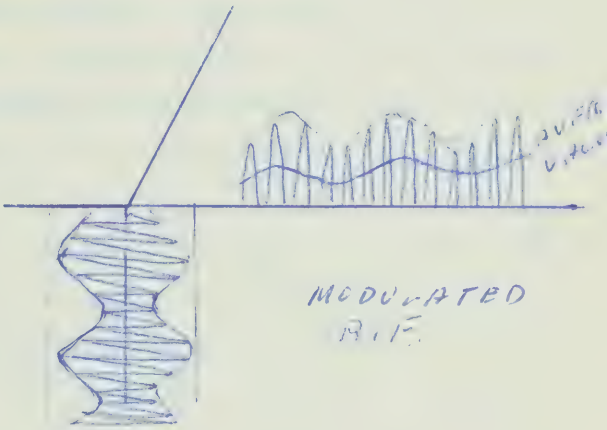
LINEAR AND SQUARE LAW DETECTORS.

NO PERFECT DEFFINITION SINCE THE DETECTOR OPERATION DEPENDS ON THE SIGNAL STRENGTH.

LINEAR DETECTORS EMPLOY COMPLETE RECTIFICATION. THE IDEAL LINEAR DETECTOR OPERATES ON A CHARACTERISTIC LINE WHICH IS STRAIGHT, RAISING AT AN ANGLE FROM THE ZERO CURRENT AXIS.



UNMODULATE

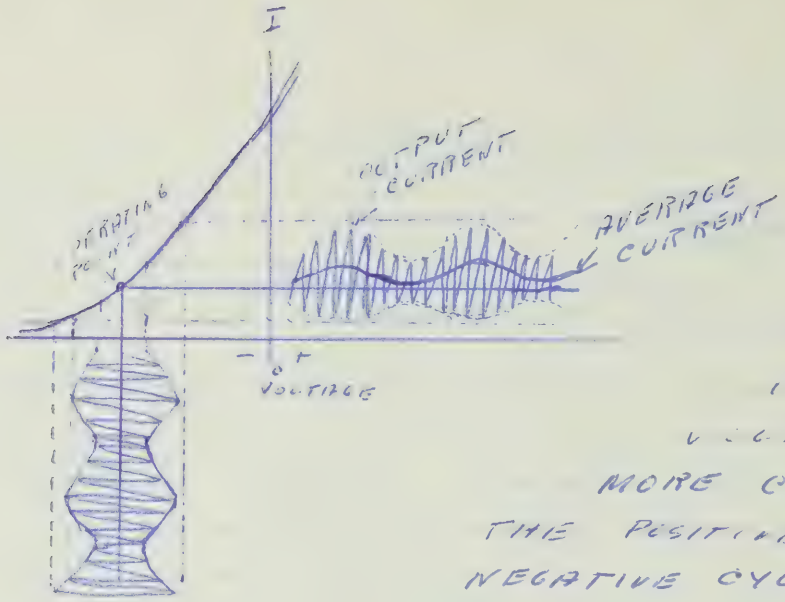


MODULATED R.F.

AN UNMODULATED SIGNAL AT THE OUTPUT OF THE DETECTOR (LINEAR) WILL ~~SHOW~~ THE RECTIFIED PULSES WITH AN AVERAGE VALUE, WHICH CAN BE MEASURED WITH A D.C. MILLIAMMETER.

THE MODULATE OUTPUT OF A LINEAR DETECTOR WILL SHOW A SERIES OF PULSES. THE PEAKS CORRESPOND TO THE VARIATIONS, OF THE MODULATION. THE AVERAGE VALUE OF THE PEAKS, ALSO CORRESPOND TO THE VARIATIONS IN MODULATION.

SQUARE LAW DETECTORS: EMPLOY PARTIAL RECTIFICATION, OBTAINED THROUGH OPERATION ON A NON-LINEAR PART OF THE E-I CURVE, OR CHARACTERISTIC CURVE.

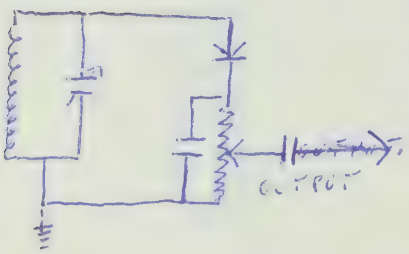


THE OPERATING POINT IS FIXED BY THE BIAS VOLTAGE.

MORE CURRENT IS PASSED IN THE POSITIVE CYCLES THAN THE NEGATIVE CYCLES.

THE AVERAGE VALUE OF CURRENT IS THE ORIGINAL A.F. SIGNAL.

CRYSTAL DETECTOR



THE CRYSTAL DIODE WILL CONDUCT ONLY IN THE POSITIVE CYCLES, THEREFORE RECTIFICATION WILL OCCURS.

THE OUTPUT WILL APPEAR ACROSS THE LOAD RESISTOR.

THE CAP. ACROSS THE LOAD WILL BY-PASS THE HIGH FR. R.F. SINCE IT'S VALUE IS RELATIVELY SMALL, IT WILL OFFER LOW IMPEDANCE TO THE R.F. AND HIGH IMPEDANCE TO THE A.F.

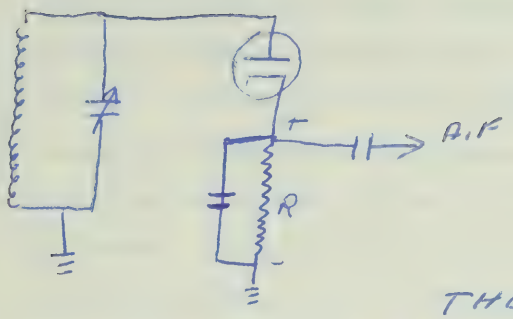
GOOD FOR: HIGH FR. NO INTERELECTRODE CAP.
NO FILAMENT NEEDED
LITTLE DISTORTION

NO GOOD FOR: HIGH CURRENT.

MAY BE OPERATED: LINEAR OR SQUARE, MOSTLY USED SQUARE ~~BECAUSE~~ WHERE LOW VOLTAGE AND LOW LOAD RESISTANCE ARE USED.

DIODE DETECTOR: TUBE.

VERY MUCH THE SAME THAN THE CRYSTAL DETECTOR. IT IS MORE STABLE, AND CAN DELIVER MORE POWER OUTPUT. AND OF VERY LOW DISTORTION IF PROPERLY OPERATED.



THE TUBE WILL RECTIFY AND THE AUDIO WILL APPEAR ACROSS THE RESISTOR. THE CAPACITOR WILL BY-PASS THE R.F. AND THE COUPLING CAP. WILL BLOCK D.C.

THE VALUE OF THE RESISTOR. FROM 1/4 TO 1 MEG.

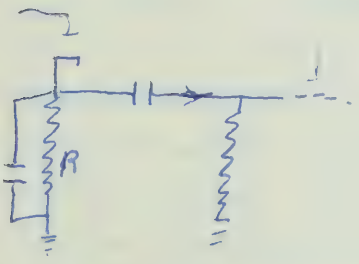
THE CAP. FROM 100 TO 250 MMFD. A COMBINATION OF LOAD AND CAP. SHOULD BE PICKE SO THAT THE CAP. OFFERS HIGH REACTANCE TO A.F AND LOW REACTANCE TO R.F.

A HIGH LOAD RESISTOR WILL DECREASE THE EFFECT OF THE CURVATURE OF THE DIODE CHARACTERISTIC CURVE. THIS TYPE OF DETECTOR HAS A DRAWBACK: WHEN THE PLATE IS POSITIVE AND CURRENT IS FLOWING IN THE CKT, IT ACTS LIKE A LOW IMPEDANCE AND DRAWS POWER FROM THE INPUT CKT. LOADING IT UP AND LOWERING THE Q. DECREASING THE SELECTIVITY AND SENSITIVITY.

A HIGH LOAD RESIS. HELPS REDUCE THE POWER DRAWN.

R.C COUPLING USED TO FEED AUDIO TO NEXT STAGE.

SINCE THE LOAD R1 IS IN PARALELL WITH THE GRID RESISTOR OF THE NEXT STAGE, AND THE LOAD IS USUALLY HIGH, TO AN UNMODULATED SIGNAL THE DIODE R1 IS THE ONLY LOAD SINCE THE BLOCKING CAP. WILL NOT PASS D.C.



WHEN THE SIGNAL IS MODULATED, BOTH RESISTORS ACT AS THE LOAD SINCE THE BLOCKING CAP. WILL PASS A.C.

THIS LOWER EFFECTIVE LOAD WILL CAUSE LOWER SENSITIVITY AND DISTORTION.

THE DISTORTION CAUSED IS THE FLATTENING OF THE NEGATIVE SIDE OF THE R.F WAVE CALLED "NEGATIVE PEAK CLIPPING"

ONE METHOD OF REDUCING THIS DISTORTION IS TO TAP ONLY PART OF THE VOLTAGE DEVELOPED ON THE LOAD. THIS EFFECTIBLY REDUCES THE LOADING OF THE GRID RESISTOR. ALSO THE VOLTAGE SUPPLIED TO THE AMPLIFIER IS REDUCED, BUT THIS CAN BE MADE UP BY MORE AMPLIFICATION.

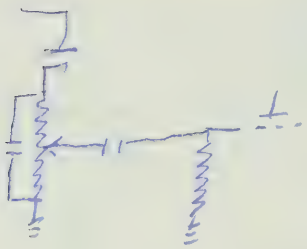
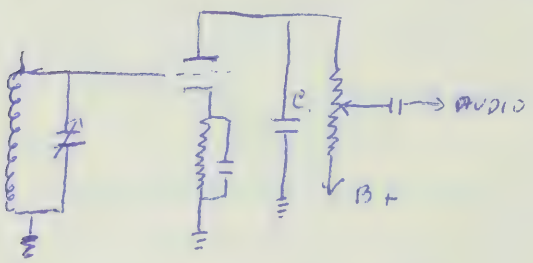
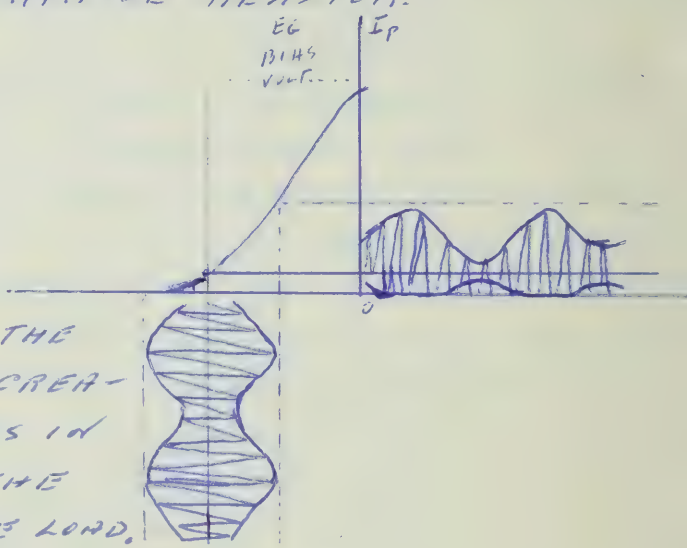


PLATE DETECTION (TRIODE)

IN A TRIODE IN ORDER THA RECTIFICATION MAY BE ACOMPLISHED, THE TUBE MUST BE DRIVEN TO CUTT OFF ON THE NEGATIVE SIDES. SINCE THE SIGNAL IS NOT ABLE TO DO THIS, THE TUBE MUST BE BIAS AT OR JUST ABOVE CUTOFF. GRID BIAS MAY BE OBTAIN BY CATHODE RESISTOR.





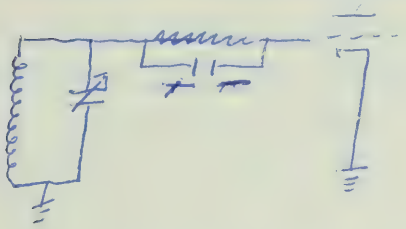
THE TRIODE RECTIFIES AS THE ~~GRID~~ POSITIVE SIGNAL DECREASES THE BIAS. THE CHANGES IN PLATE CURRENT CONTAIN THE R.F. VARIATIONS ACROSS THE LOAD. THE R.F. COMPONENT IS BY PASSED TO GROUND BY THE CAP.

IF THE SIGNAL LEVEL IS LOW, THE CURVATURE OF THE CHARACTERISTIC LINE WILL PRODUCE SQUARE LAW DETECTION, SINCE THE SIGNAL WILL NOT MOVE THE BIAS TO A STRAIGHT PORTION OF THE LINE. HOWEVER FOR STRONG SIGNALS IT WILL OPERATE AS A LINEAR DETECTOR. THIS TYPE OF DETECTOR WILL AMPLIFY THE SIGNAL. ALSO WILL CAUSE MORE DISTORTION AT LOW SIGNAL LEVELS AND IF THE MODULATION IS TOO GREAT

GRID LEAK DETECTOR

THE GRID LEAK DETECTOR IS BASICALLY A TRIODE TUBE USED AS A DIODE DETECTOR WITH A BUILT-IN AMPLIFIER. THE DIODE SECTION BEING THE CATHODE AND THE GRID ACTING AS A PLATE.

LETS CONSIDER THE GRID CKT FIRST.



FIRST WE'LL ASSUME THAT AN UNMODULATED CARRIER IS RECEIVED.

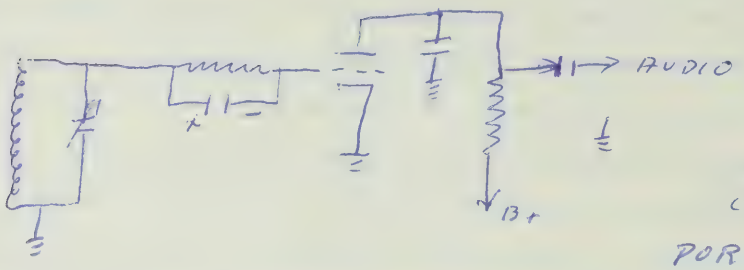
RECTIFICATION TAKES PLACE ON THE POSITIVE PORTIONS OF THE R.F CYCLES, WITH THE GRID DRAWING CURRENT. THE GRID LEAK RESISTOR FORMS THE LOAD FOR THE DIODE, AND THE CAPACITOR FORMS THE BY-PASS CAP. AS THE GRID DRAWS CURRENT, THE CAP. CHARGES ALMOST TO THE PEAK OF THE R.F. CARRIER. THE CAP. WILL ASSUME A NEGATIVE POLARITY AT THE GRID SIDE. THIS NEGATIVE VALUE IS THE OPERATING BIAS FOR THE TRIODE AND IT REMAINS CONSTANT AS LONG AS THE R.F. PEAKS ARE NOT VARIED.

SUMMING UP SOFAR; AN UNMODULATED CARRIER, PRODUCES A STEADY D.C. BIAS, AN A STEADY D.C. VOLTAGE ON THE PLATE. NOW IF THE CARRIER IS MODULATED, ~~THE GRID WILL BECOME MORE POSITIVE ON~~ THE R.F. CARRIER AMPLITUD WILL VARY. WHEN THE CARRIER AMPLITUD INCREASES, THE GRID WILL DRAW MORE CURRENT, AND THE VOLTAGE DROP ACROSS THE RESISTOR WILL INCREASE, RESULTIN ON AN INCREASE OF THE NEGATIVE BIAS, CUTTING DOWN THE TUBE CURRENT AND INCREASING THE PLATE VOLTAGE. WHEN THE R.F. AMPLITUD DECREASES, THE CONDENSER DISCHARGES THROUGH THE RESISTOR, REDUCING THE INSTANTANEOUS VALUE OF BIAS. THE TUBE CURRENT INCREASES AND THE PLATE VOLTAGE DECREASES.

NOW THEN, SINCE GRID CURRENT FLOWS ONLY IN THE IN THE POSITIVE HALF OF THE MODULATED SIGNAL DETECTION THEN IS OBTAIN IN THE GRID LEAK RESISTOR & CAP.

CONSIDERING THE WHOLE TUBE. SINCE THE RECTIFIED SIGNAL IS VARYING THE BIAS AT THE MODULATION RATE, THEN THE PLATE VOLTAGE OF THE TRIODE

WILL FOLLOW THE ORIGINAL AUDIO SIGNAL AT THE GRID. IN OTHER WORDS NO PHASE SHIFT



SINCE THE TRIODE PLATE CURRENT IS DETERMINED BY THE GRID VOLTAGE, THE PLA CURRENT WILL VARY IN P PORTION TO THE VOLTAG ACROSS THE GRID LEAK RES. THE VOLTAGE DROPPED ACRO THE LOAD, PRODUCED BY THE VARIATIONS OF THE CURR NT WILL THEREFORE BE AN AMPLIFIED REPRODU TION OF THE VOLTAGE ACROSS THE GRID RES.

THE AVERAGE PLATE CURRENT DECREASES AS THE SIGNA BECOMES GREATER.

THE CAP. TO GROUND ON THE PLATE CKT IS TO BYPASS ANY R.F. IN THE PLATE CKT.

COMMON VALUES; GRID R. 1 - 3 MEG.
" C. 100 - 250 MMFD
PLATE C. .001 MFD.

THE GRID LEAK DETECTOR - DETECTS BY SQUARE-LAW. THE PLATE CKT, SHOULD OPERATE ON THE LINEAR POR- TION, OF IT'S CHARACTERISTICS CURVE. THIS REQUIRES THAT THE PLATE VOLTAGE BE MAINTENED LOW - 25 - 75 VOLTS.

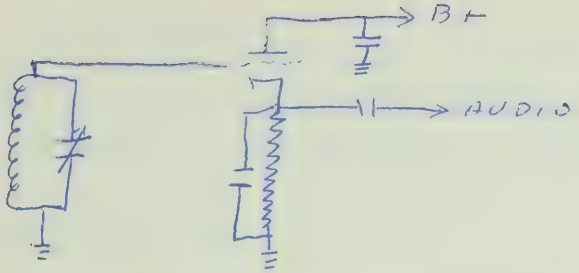
GRID LEAK DETECTORS ARE VERY SENSITIVE AND, THEREFOR GOOD FOR WEAK SIGNALS. HOWEVER SINCE IT OPERATES ON THE CURVED PORTION, ON MODERATE TO STRONG SIGNALS THE OUTPUT IS DISTORTED.

IT CAN BE OPERATED AS A LINEAR DETECTOR BY REDUCING THE GRID LEAK RES. AND MAKING THE INPUT SIGNAL LARGE.

THE DIODE DETECTOR DRAWS CURRENT FROM THE TUNING CKT, AND REDUCES IT'S SELECTIVITY.

INFINITE - IMPEDANCE DETECTOR.

THE CKT RESEMBLES A CATHODE FOLLOWER. THE DIFFERENCE IS THAT THE CATHODE RESISTOR IS MADE VERY LARGE SO THAT WITH NO INPUT SIGNAL, THE PLATE CURRENT IS APPROXIMATELY ZERO

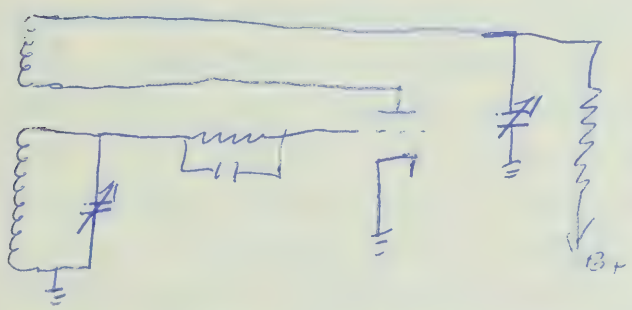


THE OUTPUT IS TAKEN FROM THE CATHODE RESISTOR. THE BY-PASS CAP. IN THE CATHODE CKT FOR R.F. THE CAP. IN THE PLATE CKT TO KEEP THE AUDIO FR. OUT OF THE POWER SUPPLY.

AS RESULT OF DEGENERATIVE FEEDBACK AMPLIFICATION IS LOST, BUT THE DISTORTION IS GREATLY REDUCED THIS CKT. WILL OPERATE WIDE LEVELS OF INPUT SIGNAL.

THE ADVANTAGE IS THAT THE GRID IS ALWAYS NEGATIVE AND DOES NOT DRAW CURRENT FROM THE TUNING CKT.

REGENERATIVE DETECTOR;



FEEDING SOME OF THE OUTPUT VOLTAGE TO THE INPUT, SO THAT IT HELPS THE ORIGINAL SIGNAL IS REGENERATION. THIS INCREASES THE AMPLIFICATION.

THE DETECTOR IS BASICALLY A GRID LEAK DETECT. EXCEPT THE FEEDBACK ACCOMPLISHED THROUGH THE TICKLER COIL. IF THE FEEDBACK IS NOT CONTROLLED THE CKT WILL BREACK INTO OSCILLATIONS, THEREFORE THE VARIABLE CAP. IN THE PLATE CKT IS USED TO BRING THE TUBE UP TO THE POINT OF OSCILLATIONS. THIS CAP VARIES FROM 100 - 250 MMFD.

THIS DETEC. IS VERY SENSITIVE, WITH GOOD SELECTIVITY, HOWEVER SINCE IS A SQUARE-LAW IT PRODUCES DISTORTION ON STRONG SIGNALS.

SUPERREGENERATIVE, USES A SQUELCH OSCILL. TO BLOCK THE TUBE ONCE IT BREAKS INTO OSCILLATION BY PLACING A POSITIVE VOLTAGE ON THE GRID IT STARTS AGAIN.

THE [redacted] RECEIVER.

THREE BASIC CHARACTERISTICS OF A RECEIVER. SENSITIVITY, SELECTIVITY AND TONE FIDELIT

SENSITIVITY: INDICATION OF OVER-ALL AMPLIFICATION.
SELECTIVITY: INDICATION OF ABILITY TO DISCRIMINATE BETWEEN SIGNALS.
THE TONE FIDELITY INDICATES HOW WELL IT REPRODUCES THE R.F. MODULATION.

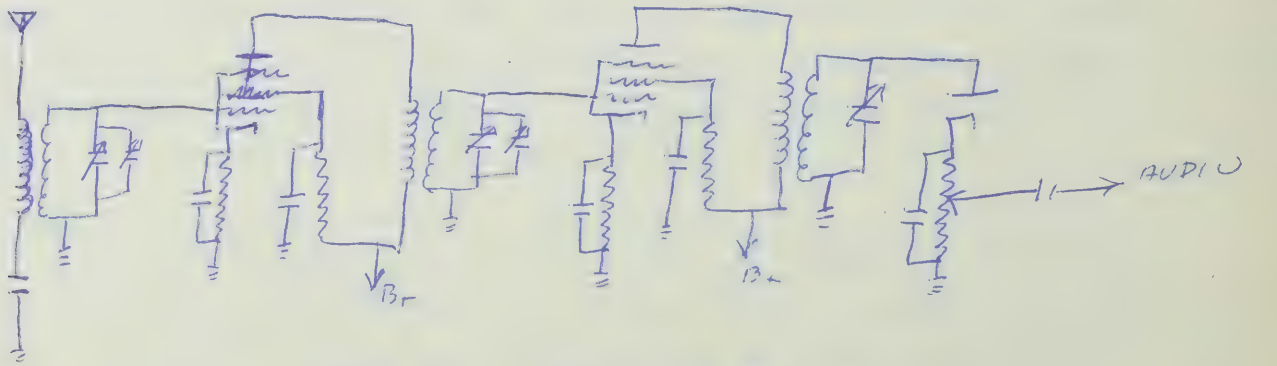
THE T.R.F. RECEIVER:

IF A DETECTOR PRECEDED BY ONE OR MORE STAGES OF R.F AMPLIFICATION, AND FOLLOWED BY AUDIO AMPLIFIER, IT IS A TRF SET.

THE TUNED CKTS ARE TUNED SIMULTANEOUSLY BY GANGED CAP. PENTODES ARE USED, TRANSFORMER COUPLED, THE PRIMARY HIGH INDUCTANCE (4 mh) THE SECONDARY DEPENDS ON THE CAPACITORS. (USUALLY 270 mh. WITH A CAP. FROM 15 TO 300 mmfd).

TRIODES ARE NOT USED, BECAUSE THE NEE FOR NEUTRALIZATION FOR OSCILLATIONS.

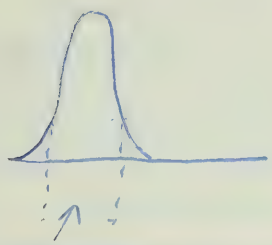
IT IS DIFICULT TO TUNED ALL THE CKT PERFECT AT THE SAME TIME WITH THE GANG CAP. AND THE VALUES OF ALL COMPONENTS IS NOT EXACTLY THE SAME. TO COMPENSATE FOR THIS SMALL TRIMERS ARE CONNECTED IN PARALELL WITH THE TUNNING CAP.



T.R.F. RECEIVER

THE SELECTIVITY OF A T.R.F. DEPENDS ON THE CHARACTERISTICS OF THE XFORMERS. THE Q CONFIRMS THE SELECTIVITY. THE SELECTIVITY IS HIGH AT LOW FR. AND LOW AT HIGH FR. DUE TO THE CHANGE IN R. OF THE CKT.

THE TUNE CKT CAN BE MADE FOR WIDE BAND PASS. THE WIDER THE BAND PASS, THE MORE OF THE MODULATING FR. CAN BE PASSED.



NORMAL BAND PASS OF A T.R.F.

THE T.R.F. DUE TO IT'S WIDE BAND PASS IS NOT TOO SELECTIVE. IN HIGH FR. WHERE THERE ARE MORE CROWDED STATIONS IT IS UNABLE TO SEPARATE THEM.

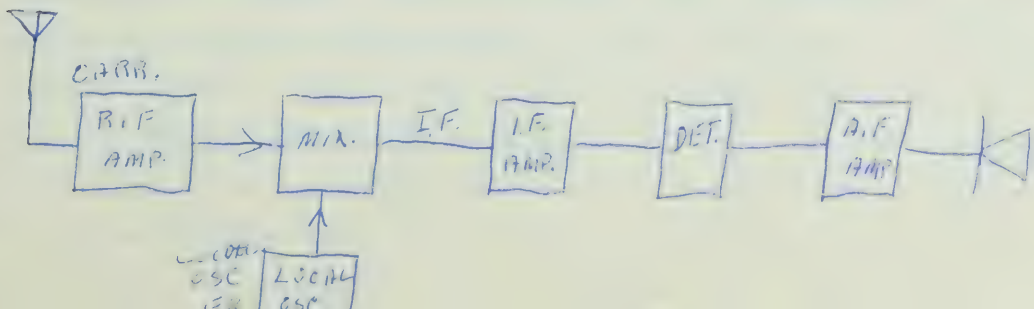
SUPERHETERODYNE RECEIVER.

TO PROVIDE FOR BETTER SELECTIVE AT HIGHER FR. AND BETTER STABILITY THE SUPERHET.

IN THE SUPERHET. ALL FR. RECEIVED ARE CHANGE TO A LOWER PRESELECTED FR. CALLED ITERMIDIATE FR. (I.F). MOST OF THE AMPLIFICATION IS CARRIED OUT AT THE I.F. AFTER I.F. AMPLIFICATION, DEMODULATION TAKES PLACE.

THE CHANGING TO A LOWER FR. IS DONE BY THE HETERODINE ACTION, WICH IS SYMPLE ADDING TWO FR. TO PRODUCE TWO MORE.

THE CARRIER FR. IS SELECTED BY A R.F. AMPL. AND SENT TO A "MIXER" TUBE. ALSO FEEDING A SIGNAL TO THE MIXER IS THE LOCAL OSCILL. THE OUTPUT CONTAINS FOUR FR. THE TWO ORIGINALS AND THE SUM AND THE DIFFERENCE



THE MIXER STAGE IS ALSO KNOWN AS THE FIRST DETECTOR.

THE I.F FR. USED IS THE DIFFERENCE OF THE TWO ORIGINAL FR. (BEAT FREQ).
THE MODULATION IS PASED TO THE I.F.
THE CONSTANT I.F. IS KEPT BY GANGING THE TUNING CAP. OF THE R.F AMPL. AND THE LOCAL OSCILLATOR. THEREFORE THE SAME DIFFERENCE FR. WILL BE PRODUCED.

THE OSCILLATOR IS USUALLY TUNED ABOVE THE INCOMING FR. THE REASON FOR THIS IS TO REDUCE INTERFERENCE FROM IMAGE FR.

THE I.F. IS LOWER THAN THE BROADCAST BAND TO PREVENT ANY STATION FROM GOING THROUGH THE IF STAGES. AND ALSO THE LOWER THE I.F. THE MORE STABLE THE I.F. STAGES WILL BE.

IMAGE FR ARE UNWANTED SIGNAL WHICH, WHEN BEAT WITH THE OSCILLATOR FR. PRODUCE THE I.F. THIS CAN OCCOUR ANY WHERE IN THE BAND. THE IMAGE FR. CAN BE ABOVE OR BELOW THE OSCILL. FR. BY THE I.F.

EXAMPLE. THE I.F IS 455 Kc
FR. BEING RECEIVED 1000 Kc
IMAGE OSCILLATOR F 1455 Kc.

THE FR. WHICH WILL PRODUCE THE I.F IN THIS CASE IS 1455 + 455 = 1910 Kc.

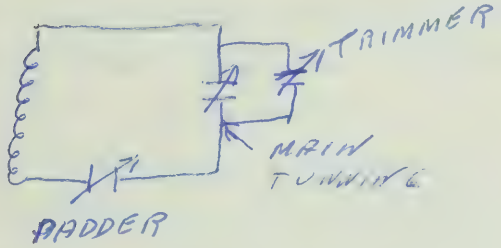
USING ONE OR MORE R.F. STAGE AS PRESELECTORS WILL REDUCE THE IMAGE-FR. RECEPTION.
THE I.F STAGES CAN BE MADE VERY SELECTIVE OR BROAD BAND. SINCE THE OUTPUT TRIANSFORMERS DRAW CURRENT THEY HAVE A LOW Q.

THE PROBLEM OF KEEPING THE OSCILLATOR FR. CONSTANT AT THE I.F. DIFFERENCE WHILE IT IS TUNED THROUGH THE BAND IS SOLVED BY SMALL TUNING CAP. CALLED TRIMERS AND PADDERS.

SINCE THE FR. OF THE OSCILLATOR IS HIGHER SMALLER CONSTANTS OF L & C ARE REQUIERED.
BY PLACING A CAP. IN SERIES WITH THE TUNING

CAP. THEREFORE REDUCING THE OVERALL CAPACITANCE OF THE CKT. AND THE CHANGE IN FR. IS LESS FOR A GIVEN AMOUNT OF ROTATION. THE VALUE OF THE PADDER (WHICH IS ADJUSTABLE) IS USUALLY THE SAME THAT THE TUNING CAP. AROUND 365 mmfd. AND IT IS TUNNED FOR TRACKING AT THE LOW END OF THE BAND.

TO TAKE CARE OF ANY FR. DEVIATIONS AT THE HIGH END OF THE BAND A SMALL TRIMMER IS CONNECTED IN PARALLEL WITH THE TUNNING CAP. AND IT IS ADJUSTED AT THE HIGH END OF THE BAND. THE VALUE IS USUALLY 1/10 THAT OF THE TUNNING CAP.



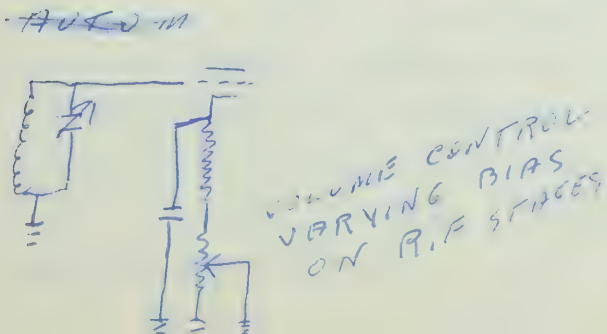
OSCILLATOR TANK

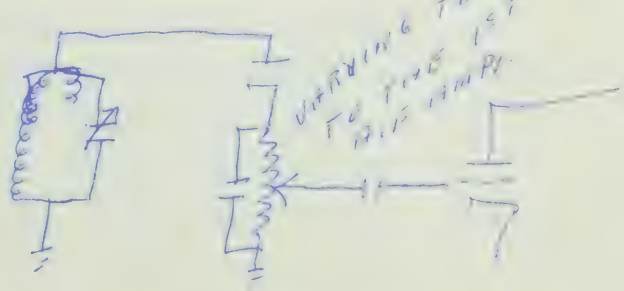
VOLUME CONTROL.

MANUAL & AUTOMATIC

MANUAL VOLUME CONTROL CAN BE OBTAIN IN MANY WAYS. BY CONTROLLING THE INPUT SIGNAL TO THE R.F OR I.F STAGES. BY CONTROLLING THE BIAS. HOWEVER USING POTS. ONTHE R.F. STAGES CAUSES NOISE TO BE PICKED-UP.

THE AUDIO TO THE SPEAKER IS USUALLY CONTROLLED BY A TAP ON THE DETECTOR LOAD OR ONTHE GRID RESISTOR OF THE 1ST AUDIO AMPL.



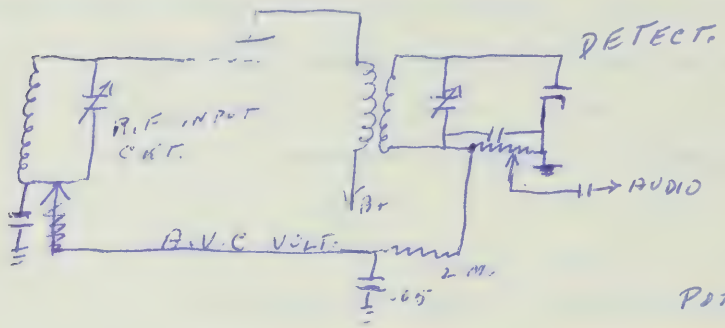


AUTOMATIC VOLUME CONTROL (A.V.C.)

THE EFFECTS OF FADDING OR BURSTING OF A RECEIVER ARE ELIMINATED BY THE A.V.C.

THIS IS ACCOMPLISHED BY VARYING THE GAIN OF THE R.F AND I.F STAGES INVERSELY WITH THE SIGNAL.

THE A.V.C. IS DESIGNED TO KEEP A CONSTANT VOLTAGE AT THE DETECTOR TERMINALS. THIS IS DONE BY VARYING THE BIAS OF THE R.F AND I.F TUBES USING THE D.C VOLTAGE PRODUCED ON THE DETECTO



THE END OF THE DETEC. LOAD RESISTOR. IS AT A NEGATIVE POTENTIAL WITH RESPECT TO THE CATHODE. THIS NEGATIVE POTENTIAL APLIED TO THE GRID OF THE RIF & I.F STAGES PROVIDE A NEGATIVE BIAS. ANY INCREASE IN SIGNAL WILL PRODUCE AN INCREASE ON THE D.C VOLT. ACROSS THE LOAD, IN TURN INCREASING THE NEGATIVE BIAS ON THE R.F & I.F STAGES, CUTTING DOWN THE GAIN AND KEEPING THE OUT PUT OF THE DETECTOR CONSTANT IF THE SIGNAL STRENGTH DECREASES THE OPPOSITE IS TRUE.

THE NEGATIVE D.C. VOLTAGE BEFORE IT CAN BE USED MUST BE FILTERED OF IT'S AUDIO COMPONENT. THIS IS DONE BY THE 2 MEG. RES. AND THE .05 CAP. THE TIME CONSTANT IS ABOUT .1 SECOND. IF THIS TIME CONSTANT IS MUCH LESS (SMALLER VALUES) THE AUDIO FR. WILL NOT BE FILTERED OUT COMPLETELY. IF THE TIME CONSTANT IS GREATER, THERE WILL BE TOO LONG DELAY BEFORE THE A.V.C. STARTS WORKING.

THE R. & C6 ON THE INPUT END OF THE R.F STAGE ARE DECOUPLING NETWORKS. THEY SERVE TO ISOLATE THE A.V.C FROM DIFFERENT CKTS AND ALSO TO FILTER THE A.V.C. SOME MORE. ALSO THE CAP. SERVES TO PLACE THE TUNING CKT AT GROUND POTENTIAL TO THE R.F.

SMALLER CONSISTING OF L & C WILL NEUTRALIZE.

BY PLACING A CAP. IN SERIES WITH THE TUNING

THE R.F. TUBES CONTROLLED BY THE A.V.C. MUST BE VARIABLE-MU (REMOTE CUT-OFF) TUBES, IN ORDER TO REDUCE THEIR MUTUAL CONDUCTANCE LINEARLY AND THEREFORE REDUCE THEIR AMPLIFICATION. THIS TYPE OF TUBE IS DESIGNED TO OPERATE WITH A MINIMUM OF 3 VOLTS BIAS USUALLY PROVIDED BY A CATHODE RESISTOR AND THE A.V.C. IN SERIES WITH IT.

TO PROVIDE AVC SOMETIMES A SEPARATE DETECTOR IS USED.

THE VALUE OF THE A.V.C. IS THE AVERAGE VALUE OF THE R.F. CARRIER.

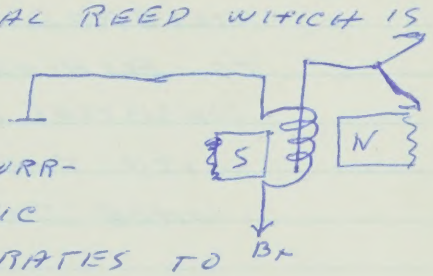
DELAYED AVC

A DISADVANTAGE OF SIMPLE A.V.C. IS THAT IT REDUCES THE WEAK SIGNALS SLIGHTLY. AN ADAPTATION WHICH AVOIDS THIS IS THE DELAYED A.V.C. (D.A.V.C). THIS USES A DUO-DIODE, ONE FOR DETECTOR AND ONE FOR A.V.C.

D.A.V.C IS ACOMPLISHED BY PLACING A SMALL POSITIVE POTENTIAL ON THE A.V.C. THE NEGATIVE POTENTIAL PRODUCED BY THE STRONG SIGNALS MUST OVERCOME THIS POSITIVE POTENTIAL BEFORE IT AFFECTS THE BIAS, THEREFORE THERE IS NO A.V.C ON WEAK SIGNALS.

SPEAKERS:

MAGNETIC; THIS TYPE USES A METAL REED WHICH IS ATTACHED TO THE CONE. THIS REED IS THE CORE TO A COIL IN THE PLATE CKT OF THE POWER AMP. AS THE CURRENT IN THE CKT VARIES. THE MAGNETIC FIELD CHANGES AND THE REED VIBRATES TO MOVE THE CONE. THIS TYPE CAN NOT HANDLE TOO MUCH ENERGY.

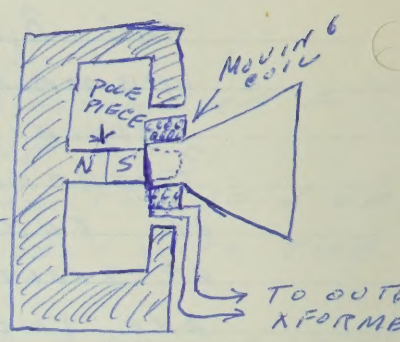


DYNAMIC SPEAKERS;

PERMANENT MAGNET (P.M) AND ELECTROMAGNETIC OR ELECTRODYNAMIC;

THE DYNAMIC SPEAKER IS ALSO KNOWN AS THE MOVING COIL.

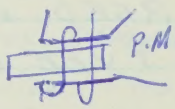
P.M.: THE MOVING COIL OR VOICE COIL IS FREE TO MOVE IN AND OUT OF THE CORE, BETWEEN THE MAGNETS. THE COIL IS ATACHED TO THE APEX OF THE CONE. THE AUDIO FR. FROM THE OUTPUT STAGE ARE PASSED ~~TO THE~~ THROUGH THE VOICE COIL. WHEN THIS A.C. FLOWS THROUGH THE COIL IT COUNTER ACTS THE MAGNETIC FIELD SET UP BY THE P.M. AND IT MAKES THE COIL MOVE AT THE RATE OF CHANGE OF THE AUDIO CURREN THE VOICE COIL IMPEDANCE IS SMALL & 2-15 OHMS. AND IS FAIRLY CONSTANT OVER THE AUDIO FR. RAISING AT HIGH FR. BECAUSE OF THE INDUCTANCE OF THE COIL.

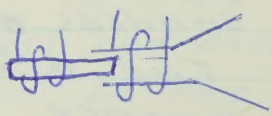


THE CLEARANCE OF THE VOICE COIL IS USUALLY IN THOU-SANDS OF INCHES.

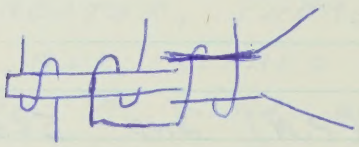
THE ELECTRODYNAMIC SPEAKER USES A D.C. TO ENER-GIZE THE MAGNETIC FIELD. OTHER WISE IT IS EXACTLY THE SAME AS THE P.M.
THE FIELD EXCITATION USUALLY COMES FROM THE POWER SUPPLY, SOMETIMES USING THE FIELD COIL AS THE FILTER CHOKE. THE FIEL COIL HAS A VALUE OF 200-500 Ω D.C. SINCE THIS CURRENT MAY NOT BE FILTERED HUM MAY BE PICKED UP BY THE SPEAKER. TO ELIMINATE THIS HUM-BUCKING COILS ARE USED. CONSISTING OF A FEW TURNS ON THE POLE PIECE IT SERIES WITH THE VOICE COIL. THIS WILL CANCELL THE HUM SINCE THE COILS ARE BUCKING EACHOTHER.

SYMBOLS:





ELECTRO DYNAMIC.



HUM-BUCKING